STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
P.O. Box 47600 • Olympia, Washington 98504-7600
(360) 407-6000 • TDD Only (Hearing Impaired) (360) 407-6006

January 31, 2003

Dear Reviewers and Interested Parties:

Subject*: Final Supplemental Environmental Impact Statement for Diquat Dibromide*

The Washington State Department of Ecology (Ecology) Water Quality Program has completed the *Final Supplemental Environmental Impact Statement (FSEIS) for Diquat Dibromide.* Diquat dibromide (label name Reward®) is an aquatic contact herbicide and algaecide. Ecology proposes to approve diquat as one of the many tools available to control aquatic nuisance and noxious plants in the public water bodies of Washington State. The FSEIS is meant to assess and summarize the potential impacts that diquat may have on the environment and propose mitigation measures. Mitigation measures are being proposed for permit conditions in two General Permits regulating herbicide use for aquatic noxious and nuisance aquatic plant control.

In 1980, Ecology completed the *Environmental Impact Statement (EIS) for Aquatic Plant Management* to evaluate and mitigate impacts of aquatic herbicides used for the control of aquatic vegetation in waters of the state. In 1991 the *Draft Supplemental Environmental Impact Statement for the Aquatic Plant Management* followed by the *Final Supplemental Environmental Impact Statement for the Aquatic Plant Management* in 1992 evaluated several herbicides and was updated again in 2001 to evaluate 2,4-D and endothall. Diquat was neither permitted at that time nor in 1980 due to lack of critical information. Since then, Risk Assessments for diquat were compiled and significant questions were answered. The enclosed FSEIS evaluates the aquatic herbicide diquat dibromide previously not permitted by Ecology.

Diquat is beneficial because it has the ability to burn back noxious as well as nuisance aquatic plants. Diquat is eliminated from the water body quickly and is relatively inexpensive compared to other chemical weed control methods. Diquat is effective for spot treatments of submersed aquatic plants.

As with most chemical methods of aquatic weed control, diquat has significant adverse environmental impacts. The enclosed FSEIS explains the associated adverse impacts and includes the mitigations necessary to alleviate those impacts. Because diquat is a non-selective herbicide, it affects target as well as non-target plants. Diquat must be monitored closely because it accumulates in sediment and soil after each application; however, the most current risk assessments indicate that diquat is not biologically available when bound to sediment and soil. In addition, diquat is highly toxic to some invertebrates and moderately toxic to birds and amphibians. However, if diquat is applied at standard rates and the mitigations included in the FSEIS are followed, then diquat is relatively safe to use in the environment.

Decision makers may want to consider that some data gaps remain regarding diquat. Toxicological studies have not been completed for many aquatic species native to Washington, including the state listed western pond turtle and significant species such as the spotted frog, northern leopard frog and Woodhouse toad. A timing table from the Washington Sate Department of Fish and Wildlife (WDFW) is a critical mitigation tool expected to protect anadromous species but is not yet completed. WDFW anticipates that the timing table will be ready in the early part of 2003. Data regarding diquat's persistence in sediment and soil is only reflected over a 40 year time period. The environmental impacts of diquat accumulating in soil and sediment beyond that time have not been investigated.

Thank you for your participation in this important issue. The waters of the state are vital to all of us and we appreciate your participation in their protection.

Sincerely,

Megan White

Megan White, P.E., Manager
Water Quality Program

ke:ak
Enclosure

Final Supplemental Environmental Impact Statement for Diquat Dibromide

The Water Quality Program

WASHINGTON STATE DEPARTMENT OF ECOLOGY

November 2002
Publication Number 02-10-052

Printed on Recycled Paper

Final Supplemental Environmental Impact Statement for Diquat Dibromide

The Water Quality Program

Prepared by:

Kathleen Emmett
Washington State Department of Ecology
Water Quality Program

November 2002
Publication Number 02-10-052

Printed on Recycled Paper

For additional copies of this document, contact:

Department of Ecology
Publications Distribution Center
PO Box 47600
Olympia, WA 98504-7600
Telephone: (360) 407-7472

Fact Sheet

Project Title:	State of Washington Aquatic Plant Management Program
Proposed Action:	The Proposed Action is a Supplement to the Department of Ecology's 1980 Environmental Impact Statement for aquatic plant management, which addressed the application of aquatic herbicides to freshwater. The action is a non-project proposal under State Environmental Policy Act (SEPA) rules and the Environmental Impact Statement (EIS) will be integrated with on-going agency permitting procedures for aquatic herbicides. The proposal is intended to evaluate the aquatic herbicide diquat dibromide for use as a tool under the noxious and nuisance aquatic pest control general permits. The recommended alternative is an integrated aquatic plant management approach using the most effective and environmentally protective mix of vegetation control methods that may include biological, manual, mechanical and chemical methods. Other alternatives analyzed include chemical use only, mechanical use only, biological use only, and no action, which is the continuation of current policy.
Lead Agency:	Washington State Department of Ecology
Responsible Official:	Megan White, Water Quality Program Manager
Contact Person:	Kathleen Emmett, Water Quality Program
Licenses, Permits:	This list reflects permits required for various plant management alternatives discussed in this document, including use of aquatic herbicides, rotovation, dredging, manual and biological control methods. Not all permits listed below are required for all activities discussed in this document. Requirements may change; please check with resource agencies to determine permits requirements for a particular project. An overview of state programs for aquatic pesticide regulation is provided in Section I.

Ecology:	National Pollutant Discharge Elimination System Waste Discharge General Permit
Fish and Wildlife:	Hydraulic Project Approval Fish Planting Permit
Local:	Substantial Development Permit (Shoreline) in certain locales
Federal:	Section 404 Permit from the Army Corps of Engineers

Contract Authors and Principle Contributors:

Bernalyn D. McGaughey, Risk Assessment Project Manager
Compliance Services International
1112 Alexander Avenue E.
Tacoma, Washington 98421

Robert G. Dykeman, MS University of Washington (Fisheries Science, minor Aquatic Biology); BS University of Washington (Fisheries, minor Limnology, Freshwater Biology), AS Tacoma Community College (Sciences).

Jon E. Ford, Ph.D., Wayne State University, School of Medicine, (Psychology and Pharmacology); MS Wayne State University, School of Medicine, (Occupational and Environmental Health); BS Lewis and Clark College, (Biology and Psychology).
Stephen O. Jacobson, BA University of Washington, (Chemistry).
Richard P. Kemman, MS Clemson University, (Environmental Toxicology); BA Whitworth College, (Biology).
Thomas M. Priester, Ph.D. University of California, Riverdale (Entomology, Aquatic Biology and Medical Entomology). BS University of California, Irvine (Aquatic Biology and Molecular Biology).

Agency Authors and Principle Contributors:

Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Kathleen Emmett, MPA The Evergreen State College (Political Administration), BSED Eastern Montana College (English, Political Science and Education). 1999, 2000 WSDA Pesticide License No. 59189, Public Operator, Aquatic Endorsement, recert date: 00-2004.
Jessica Andreoletti, BS The Evergreen State College (Freshwater Ecology).
Kathleen S. Hamel, MS The University of Western Australia (Aquatic Ecology), BA the University of Washington.
Allen Moore, BS Biological Oceanography – University of Washington.

Issue Date of Draft SEIS:

September 30, 2002

Public Comment Period:

September 30, 2002 – November 6, 2002
If you or a member of your organization would like to review and comment on this document please forward your request to the project facilitator Jessica Andreoletti at jean461@ecy.wa.gov , by telephone at (360) 407-6482 or write to her attention at the above Ecology address.

Public Hearings And Workshops:

Location	Time/Date
Bellevue - Ecology Northwest Regional Office 3190 – 160th Avenue SE	November 5 10:30 a.m.
Spokane - Spokane Shadle Library 2111 West Wellesley	November 6 12:30 p.m.

Workshops will be held immediately before the hearings so that Department of Ecology staff can provide an overview of the proposed SEIS documents and answer questions. Ecology will receive written public comments during the hearings.

Location of Background Data:

Water Quality Program
Department of Ecology
300 Desmond Drive
Lacey, WA 98504-7600

For copies of the Final SEIS Documents: Please order directly from the Department of Printing or contact Kathleen Emmett at 360-407-6478. Order information is on the backside of the cover page to this document.

TABLE OF CONTENTS

Page

APPENDICES

Acronyms/Abbreviations

2,4-D BEE: 2,4-D butoxyethyl ester (Aqua-Kleen® and Navigate®)
2,4-D DMA: 2,4-D Dimethlyamine salt
a.i. Active Ingredient
c.e. Cation equivalent
CWA: Federal Water Pollution Control Act of 1972, known as the Clean Water Act
DNR: Washington State Department of Natural Resources
DSEIS: Draft Supplemental Environmental Impact Statement
EEC: Expected Environmental Effects Concentration
EIS: Environmental Impact Statement
EPA: Untied States Environmental Protection Agency
ESA: The Endangered Species Act
EUP: Experimental Use Permit
FSEIS: Final Supplemental Environmental Impact Statement
FIFRA: Federal Insecticide, Fungicide, and Rodenticide Act, as amended
GMA: Growth Management Act
HPA: Habitat Conservation Plan (ESA Sections 10, 16 and 1539)
HPA: Hydraulic Project Approval
IPM: Integrated Pest Management (IPM Law is Chapter 17.15 RCW)
IAVMP: Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans
IVMP: Integrated Aquatic Vegetation Management Plans
LC50: Lethal Concentration is 50%. The quantity of substance needed to kill 50% of test animals exposed to it within a specified time. This test applies to gasses, vapors, fumes and dusts.
MC: Mosquito Control Policy
MCLG: Maximum Contaminant Level Goal – The MCLG is used by EPA to regulate contaminants in drinking water under the Safe Drinking Water Act
MOS: Margin of Safety
NMFS: National Marine Fisheries Services
NOAA: National Oceanic and Atmospheric Association
NOEC: No Observable Effect Concentration
NOEL: No Observable Effect Level
NWIFC: Northwest Indian Fisheries Commission
RCW: Revised Code of Washington
RQ: Risk Quotients (the ratio of exposure concentration divided by an effects concentration)
SEIS: Supplemental Environmental Impact Statement
SEPA: State Environmental Policy Act
STM: Short-term modification of WQS, a permit per 173-201A-110 WAC
U.S.C.: United States Code
WAC: Washington Administrative Code
WDFW: Washington State Department of Fish and Wildlife
WQS: Water Quality Standards, Chapter 173-201A WAC
WSDA: Washington State Department of Agriculture
WSU: Washington State University

Summary

The State of Washington Water Pollution Control Act (RCW 90.48) and the State Surface Water Quality Standards (Chapter 173-201A WAC) require the Department of Ecology (Ecology) to establish criteria and programs necessary to protect waters of the state. These standards articulate an intent to protect public health and maintain beneficial uses of surface waters, including recreational activities such as swimming, boating, and aesthetic enjoyment; public water supply; stock watering; fish migration and fish and shellfish, rearing, spawning, and harvesting; wildlife habitat, and commerce and navigation. Water Quality Standards (WQS) specifically allow Ecology to modify water quality criteria on a short-term basis to accommodate essential activities, respond to emergencies, or otherwise protect the public interest.

The Need for Aquatic Plant Management. Aquatic plants are a valuable component of aquatic ecosystems that in normal situations require protection. Like algae, aquatic plants are a vital part of a watershed system because they provide cover, habitat and food for many species of aquatic biota, fish and wildlife. Aquatic plants also limit certain lake uses. Too many rooted and floating plants can degrade water quality, impair certain fisheries, block intakes that supply water for domestic or agricultural purposes, and interfere with navigation, recreation and aesthetics. In addition, noxious aquatic plant species such as Eurasian water milfoil can form dense populations that may pose safety problems for swimmers and boaters and can degrade wildlife habitat by out-competing native species or changing water chemistry. Consequently, Ecology's Water Quality Program receives requests for permits from various entities to use herbicides and other control methods to manage nuisance (excessive native) and noxious (invasive non-native) aquatic plant species and algae in various waterbodies. In response to these requests and in accordance with the provisions of the State Environmental Policy Act (SEPA), Ecology determined that aquatic plant management by these methods may have significant adverse environmental impacts, and that an Environmental Impact Statement was necessary.

Summary of the Proposal. In 1980, Ecology completed an *Environmental Impact Statement* (EIS) for statewide program guidance in the issuance of short-term modifications for herbicides used in aquatic plant control. Since 1980, a number of mechanical and physical methods (i.e. mechanical harvesting, rotovation, bottom barriers, and cutters) were developed and used extensively for aquatic vegetation control, and various methods of biological control have undergone research and development during the past two decades. Changes also occurred in the understanding of aquatic ecosystems, including the role of wetlands and the need to consider and control impacts such as nutrient and sediment loading within the total watershed of any particular waterbody. To address these changes and the broadening field of environmental choices in aquatic plant management including the evaluation of several herbicides, Ecology updated and supplemented the EIS with the *Final Supplemental Environmental Impact Statement* (SEIS) *for the Aquatic Plant Management Program* in 1992. In 2001, the final SEIS was updated to assess new aquatic herbicides or permit herbicides with recent label changes. This 2002 *Final SEIS for Diquat Dibromide* is an additional supplement to the 1980 EIS that proposes to evaluate diquat as another chemical tool to control noxious and nuisance aquatic plants.

In the spring of 2002, Ecology issued two new National Pollutant Discharge Elimination System Waste General Permits (NPDES) for noxious, nuisance aquatic pest control. The purpose of the two permits is to control the discharge of herbicides that become waste after treatments to eradicate noxious and nuisance weeds and algae in the waters of the state. Minor modifications may be made to these permits if diquat is allowed for use as an aquatic herbicide in Washington State.

In 1980, diquat was discontinued for use due to lack of significant information. Since that time the Environmental Protection Agency (EPA) finalized the Re-registration Eligibility Decision document (RED) and Ecology sponsored the development of risk assessments that addressed historical data gaps and offered the most sophisticated data available to date regarding diquat. An investigation of that information is included in this 2002 final SEIS.

Ecology is the primary lead for the current Final SEIS for Diquat, but has received advisory and review assistance from an Internal Committee of Ecology staff, a Technical Advisory Committee and a Steering Committee.

The Technical Advisory is comprised of representatives from state and county Noxious Weed Control Boards, county stormwater and waste water management teams, the state departments of Fish and Wildlife (WDFW), Ecology, the Syngenta Corporation, aquatic herbicide applicators and other organizations with jurisdiction and/or interest in aquatic plant control. The Steering Committee is comprised of representatives from the state departments of Agriculture, Health, Fish and Wildlife and Ecology.

The department of Agriculture (WSDA) is charged with regulating pesticide applicators, registering pesticides for use in the state, and, along with the state's Noxious Weed Control Board, controlling noxious plants within the state. The Washington State Department of Health (DOH) is charged with protection of human health. The WDFW has received requests for Hydraulic Project Approvals (HPAs) to implement various physical and mechanical methods and is charged with protecting fish and wildlife. The state departments of Natural Resources (DNR) and Ecology have concerns with the potential impact of various plant control methods on the natural resources they are charged with managing. The WDFW and the DNR are also mandated by the legislature to develop programs for controlling particular noxious emergent species on state-owned or managed lands.

A growing list of external reviewers has been commissioned to serve in a review capacity for the risk assessments and this 2002 Final SEIS for Diquat. The external list of reviewers includes representation from the committees listed above and adds representatives from the Washington Legislature, the EPA, Washington State University, National Marine Fisheries Services, National Oceanic and Atmospheric Association, U.S. Fish and Wildlife, Northwest Coalition for Alternatives to Pesticides, Washington Toxics Coalition and the Northwest Indian Fisheries Commission.

Impacts and Mitigation. Impacts and mitigation measures are discussed in detail in the risk assessments included in Appendix A of the 2002 final SEIS. The risk assessments examine the potential acute and chronic effects of single and seasonally reoccurring applications on aquatic plants and animals (invertebrates and vertebrates, and associated wildlife), including consideration of life cycles and food chain impacts. Where available, information on toxicity and potential impacts of one-time and repeated applications of diquat on numbers, diversity, and habitat of species of plants, fish, birds and other wildlife are included. Impacts (both risks and benefits) for spawning and rearing habitat used by various species, including but not limited to fresh water trout and sea run cutthroat trout are also considered. Discussions include direct and indirect impacts of herbicide treatments on the marine environment, salmonid smoltification and their survival life histories.

Impacts and mitigation measures are also addressed in the sections of this document that discuss alternative control methods. Environmental and human health impacts of diquat and alternative control methods are discussed in categories of earth, air, water and biota. Application conditions that minimize or mitigate adverse human health and environmental impacts are explored.

This current supplement recommends the Integrated Pest Management (IPM) approach as the preferred method of aquatic plant control to minimize adverse impacts. By definition, IPM uses the most efficient and effective control method, or combination of control methods, while minimizing impacts to human or environmental health. However, even under an IPM program, unavoidable, significant adverse impacts may occur that restrict other beneficial water uses. The development of a lake or aquatic plant management plan allows for the establishment of use priorities by the parties involved while maintaining and protecting the uses of a particular waterbody. Management plans help to ensure that proven control methods will be implemented for the long-term management of the waterbody and those problems such as nutrient enrichment and sediment loading, which often are the cause of accelerated plant and algae growth, are addressed. Planning further assures that aquatic plant managers will not rely on aquatic plant control methods that may only address the symptoms of such problems.

Alternatives. In subsequent documents, the environmental impacts of many chemicals were evaluated for noxious and nuisance aquatic plant control. Currently, the chemical herbicides endothall (Hydrothol® 191 and Aquathol®), fluridone, glyphosate, and 2,4-D [(2,4-dichlorophenoxy) acetic acid] have been approved as chemical alternatives to aquatic plant control. The 1992 SEIS introduced an integrated pest management approach as the preferred method of control and evaluated the use of chemical controls only, physical controls only, biological controls only, continuation of current practices, and taking no action relative to controlling nuisance aquatic plants. This 2002 SEIS evaluates diquat as a tool to control aquatic weeds in addition to the alternatives included in the 2001 supplement. Triclopyr and copper compounds are scheduled to be evaluated in 2003.

Other Considerations. This document identifies significant data gaps and other considerations that should be brought to the reader's attention. Some missing links include toxicological studies for many aquatic species native and threatened in Washington, a timing table from the WDFW expected to protect anadromous species, and an explanation of diquat's long-term environmental impacts regarding persistence.

Endangered Species Act and Wetland Issues. Special consideration is given to salmonids and other listed species under the Endangered Species Act (ESA). Ecology's Aquatic Plant Management Program requires that permits be processed or denied depending on the potential impact to ESA listed species, the seriousness of the aquatic plant problem and the degree to which integrated aquatic plant management plans have been considered. Also essential is conformance to the Governor of Washington's goal of no net loss of wetland acreage or function. Therefore each alternative must be evaluated to determine the degree to which wetlands would be impacted, consistent with policies and standards being developed by Ecology and other agencies. Within this context, a priority is given to the control of noxious aquatic plant species.

Major Conclusions. It was found that having a variety of control methods available provides the flexibility necessary to control nuisance populations of native as well as invasive non-native species in situations where it is also desirable to maintain other, often conflicting beneficial water uses. The current supplement (SEIS 2002) recommends diquat as a tool to control aquatic weeds. It supports the use of an IPM approach using the most efficient and effective control method, or combination of control methods, while minimizing impacts to human or environmental health.

Dates for Review. The review period for this 2002 Final SEIS for Diquat is from December 1, 2002 to January 1, 2002. To submit comments, please get in touch with the contact person identified in the fact sheet section of this document.

Section I. Introduction to Lake and Aquatic Plant Management

A. Background

Washington State has an abundance of surface water resources, including approximately 7,800 lakes, ponds and reservoirs, 40,492 miles of rivers and streams, and untold acres of wetlands. Within these diverse waters, there is a great range of conditions such as hardness, pH, dissolved oxygen, turbidity, nutrients, size, flow, biota and use. Citizens rely on these waterbodies for a number of uses, such as recreation in the form of swimming, fishing, boating and aesthetic enjoyment; commerce and navigation; water supply for domestic, industrial and agriculture activities; and habitat for fish and wildlife.

Our understanding of how aquatic systems function has grown during the past two decades. Aquatic systems change slowly through a natural aging process called eutrophication. This process is typified by increased productivity, structural simplification of biotic components, and a reduction in the metabolic ability of organisms to adapt growth responses to imposed changes (i.e., reduced stability) (Wetzel 1975). Advanced stages of eutrophication in aquatic systems may represent natural processes but are often out of equilibrium with respect to the freshwater chemical and biotic characteristics desired for anthropic purposes.

Many human activities have affected conditions of drainage basins, water budgets, and nutrient budgets, resulting in accelerated productivity and eutrophication. As Vallentyne described (1974), a common result of misuse of the drainage basin and the excessive loading of nutrients and sediments in fresh waters is the acceleration of eutrophication, literally turning lakes into "algal bowls" (Wetzel 1975). Accelerated eutrophication often results in increased primary productivity, including increased plant growth in shallow areas of the lake. Thus, effective treatment of excessive aquatic plant populations and algae must include controlling the introduction of nutrients and sediments from sources throughout the entire watershed.

Human activities are also often responsible for the introduction of exotic species into aquatic environments. Our increased knowledge of the function of wetlands has resulted in a reassessment of management strategies for native versus invasive species. Native species are needed to maintain or enhance an aquatic system. However, noxious species often degrade aquatic systems to a degree that may require eradication to protect and maintain established beneficial uses. The prevention, control, and eradication of noxious species needs to be given a high priority in the development of lake and watershed management plans and may require extensive control measures.

B. Goals of the 1980 Environmental Impact Statement and Supplements

The 1980 EIS addressed control of aquatic plants through the use of herbicides and examined the alternative of no action. This approach treated the symptoms but not the underlying problems of lake enrichment and aquatic plant and algae growth. The 1987 amendments to the Federal Clean Water Act required the development and implementation of programs designed to reduce or eliminate the introduction of toxic substances to our nation's waters. In addition, new scientific evidence concerning the potential impacts that certain toxic substances may have on human and aquatic life have increased public awareness regarding the intentional introduction of toxic substances to surface waters, even in situations where their introduction may enhance the uses of a waterbody. Thus, a more thorough review and analysis of the benefits of aquatic herbicides relative to the potential risks to human and environmental health was deemed warranted. Subsequently, the 1992 SEIS proposed an aquatic plant management approach that integrated herbicide use with manual, mechanical and biological methods and considered the context of whole lake and/or watershed systems.

Ecology's current aquatic plant management program encourages an understanding of natural aquatic processes, including the role of aquatic plants in a natural system, plant identification and the underlying causes of excessive plant growth. Through this process, people can make informed selections of methods for reducing nutrient and sediment loading and meeting long-term management goals. This is consistent with Ecology’s sustainability goals, which recommend the development of integrated aquatic plant management plans by communities, professional herbicide applicators, groups and others who request permits for aquatic plant management. Ideally, an aquatic plant management plan should be prepared before certain permits are issued for use of herbicides, and in regard to public waters, a wide range of participation is essential for the benefit of all users, not simply the adjacent property owners. However, in the case of new infestations of noxious (non-native) and invasive plants, early control may be necessary and preclude the development of a plan for the first season of treatment.

Addressing the potential loss of habitat or habitat disruption from aquatic plant control strategies must also be a goal in the development and implementation of any aquatic plant management program. This is especially true now that species of salmon, trout, char or steelhead have been listed in nearly every county in Washington as a candidate, a threatened or endangered species under the Endangered Species Act (ESA). Currently, Washington has 28 state candidate fish species and 3 state sensitive species including many species of marine fish. (For current listings see http://www.governor.wa.gov/esa/regions.htm.)

Wetlands have often been overlooked as a key component of aquatic systems. The value and function of wetlands is increasingly being recognized and must be incorporated into any comprehensive lake or vegetation management plan. In addition, the Governor of Washington has adopted through executive order (EO 89-10) a goal of no net loss of wetland acreage or function in the state. All management strategies for aquatic vegetation must consider this goal.

C. Aquatic Plant Control Regulation

1. Introduction

The state of Washington regulates aquatic plant control through several agencies concerned with various aspects of aquatic plant growth and control. Aquatic plants appear in many shapes and sizes. Some have leaves that float on the water surface, while others grow completely underwater. They grow wherever water is persistent, in rivers, streams, lakes, wetlands, coastlands or marine waters. In moderation, aquatic plants are aesthetically pleasing and desirable environmentally. The presence of native species is natural and normal in lakes and other water bodies because they provide important links in aquatic life systems. In large quantities, however, plants can interfere with water uses and may be seen as a problem. An over-abundance of native plants may indicate excessive nutrients (nitrogen or phosphorus) in the water column. Conversely, non-native aquatic plants and excessive plant nutrients are often a threat to the health of the aquatic environment. The introduction of non-native aquatic plants and excessive plant nutrients has created many aquatic problems for Washington waters. The removal of non-native aquatic plants from the aquatic system is often desirable and even necessary to enhance water quality and protect beneficial uses.

The management of aquatic plants under their respective jurisdictional authorities can be generally categorized by the control method used and by the type of plant controlled. In any case of uncertainty, the **Permit Assistance Center should be contacted at (360) 407-7037** before an aquatic plant removal or control project is initiated.

2. Regulatory Requirements for Manual, Mechanical and Biological Methods

Manual Methods. The Washington State Department of Fish and Wildlife (WDFW) requires either an individual or general permit called a **Hydraulic Project Approval (HPA) (**RCW 77.55.100. (14)) for all activities taking place in the water including hand pulling, raking, and cutting of aquatic plants. However, projects conducted for the control of spartina and purple loosestrife may not require an HPA. Information regarding HPA permits can be obtained from the local office of WDFW. To request a copy of the Aquatic Plants and Fish pamphlet, please contact:

WDFW
Habitat Program
600 Capitol Way N
Olympia WA 98501-1091
(360) 902-2534 http://www.wa.gov/wdfw/hab/aquaplnt/aquaplnt.htm

Mechanical Cutting. Mechanical cutting requires an HPA, obtained free of charge from WDFW. For projects costing over $2,500, check with your city or county to see if a shoreline permit is required.

Bottom Screening. Bottom screening in Washington requires hydraulic approval, obtained free from WDFW. Check with your city or county to determine whether a shoreline permit is required.

Weed Rolling. Installation of weed rolling devices requires hydraulic approval obtained free from WDFW. Check with your city or county to determine whether a shoreline permit is required.

Grass Carp and other Biological Controls. A grass carp fish-planting permit must be obtained from the WDFW, check with your regional office. Also, if inlets or outlets need to be screened, an HPA application must be completed for the screening project.

Diver Dredging. Diver dredging requires hydraulic approval from WDFW and a permit from Ecology. Check with you city or county for any local requirements before proceeding with a diver-dredging project. Diver dredging may also require a Section 404 permit from the U.S. Army Corps of Engineers.

Water Level Drawdown. Permits are required for many types of projects in lakes and streams. Check with city, county and state agencies before proceeding with a water level drawdown.

Mechanical Harvesting. Harvesting in Washington requires an HPA from WDFW. Some Shoreline Master Programs may also require permits for harvesting. Check with your city or county government.

Rotovation. Rotovation requires several permits, including 1) an HPA from WDFW, 2) a permit from an Ecology regional office, 3) a shoreline permit from the city or county may also be needed, and 4) a Section 404 permit obtained from the Army Corps of Engineers may be required.

3. Regulatory Requirements for Aquatic Herbicide Applications

Ecology utilizes a permit system based primarily on SEPA guidance documents for implementing the requirements of the Water Quality Standards (WQS). A short-term modification (permit) may be issued by Ecology to an individual or entity proposing the aquatic application of pesticides, including but not limited to those used for control of federally or state listed noxious and invasive species, and excess populations of native aquatic plants, mosquitoes, burrowing shrimp, and fish.

Ecology is the primary lead for regulating pesticides used in aquatic environments under Washington State's Water Pollution Control Law, Chapter 90.48 RCW. However, the state departments of Agriculture, Health, Fish and Wildlife, Natural Resources, and the State Noxious Weed Control Board are agencies with jurisdiction and/or interest in aquatic plant control and may review Ecology permits.

Laws and Codes. Several sections of the State Water Pollution Control Law and Washington's Administrative Code apply directly to the use of aquatic pesticides, including:

- RCW 17.15.010, Integrated pest management
- RCW 17.15.020 Implementation of integrated pest management practices
- RCW 90.48.010 Water Pollution Control Policy enunciated
- RCW 90.48.260 Federal clean water act -- Department designated as state agency, authority -- Powers, duties and functions.
- RCW 90.48.445 Aquatic noxious weed control
- RCW 90.48.447 Aquatic plant management program -- Commercial herbicide information -- Experimental application of herbicides -- Appropriation for study.
- RCW 90.48.448 Eurasian water milfoil -- Pesticide 2,4-D application.
- WAC 173-201A-110 Short-term Modifications
- WAC 173-201A-030 Lake Class Water Quality Criteria

Copies of laws and codes pertinent to aquatic plant management can be found in Appendix B.

Note: Permit coverages are issued for five years when issued when the activity is part of an ongoing or long-term operation and maintenance plan, integrated pest or noxious weed management plan, waterbody or watershed management plan, or restoration plan. Such a plan must be developed through a public involvement process…and be in compliance with SEPA...in which case the standards may be modified for the duration of the plan, or for five years, whichever is less.

EIS Guidance. In 1980, Ecology completed a Final Environmental Impact Statement (FEIS) for a statewide Aquatic Plant Management Program based primarily on aquatic herbicide use. The 1992 *Aquatic Plant Management Program's Final Supplemental Environmental Impact Statement* (Hardy, et al. 1992) updated the EIS and Ecology regional offices issue site-specific permits for the use of the aquatic herbicides based on this guidance. This current final SEIS supplements the 2001 SEIS and provides guidance for IPM control methods, and the aquatic herbicide diquat, glyphosate, fluridone and copper compounds. Diquat is used in Washington State to control of many submersed and floating nuisance and noxious aquatic plants including algae.

Through our permitting program, Ecology encourages the use of an integrated management plan that includes the selection, integration, and implementation of proven control methods based on predicted economic, ecological, and sociological consequences. This concept is based on the premise that, in many cases, no single control method will by itself be totally successful. Thus, a variety of biological, physical, and chemical control and habitat modification techniques are integrated into a cohesive plan developed to provide long-term vegetation control. Integrated management also includes various land-use practices necessary to reduce or eliminate the introduction of nutrients and sediments that may be the cause of accelerated aquatic plant and/or algae growth. The ultimate objective is to control detrimental vegetation in an economically efficient and environmentally sound manner. This is also the only method where Ecology may authorize a longer duration permit.

In addition to the regionally administered permits for Spartina that are multi-year and multi-county, Ecology issues a general permit of coverage for all noxious and nuisance weed control activities. This SEIS is being used as Ecology's primary guidance document for permitting the use of diquat to control aquatic plants. The WSDA, through licensed applicators, treats (with aquatic endorsements) the following noxious aquatic plants: purple loostrife, garden loostrife, wand loostrife, Japanese knotweed, indigo-brush, meadow knapwood, saltcedar and reed canary grass. Each licensed applicator must follow the requirements of the permit. For further details, contact the WSDA Weed Specialist in Yakima at ghaubrich@agr.wa.gov or (509) 225-2604.

ESA Considerations. Several salmon populations and other aquatic biota are listed for special protection under the Endangered Species Act (ESA). Listings may affect aquatic control projects all over Washington State. Information regarding potential listings of endangered species in particular water bodies can be obtained from the local office of the Washington Department of Fish and Wildlife or on their website at: http://www.governor.wa.gov/esa/regions.htm.

Obtaining a permit from Ecology for the application of herbicides does not exempt an applicator from "Take" liability under ESA. "Take" means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in such conduct" with respect to a species listed under ESA (16 U.S.C. Section 1532(19)). Current permit applications require applicators to state whether the waterbody proposed for treatment is part of a designated critical habitat of an ESA listed species or if the waterbody is in an Evolutionary Significant Unit listed under ESA. Proposed treatments that may have an adverse impact on a listed species may be denied or restricted for their protection.

Ecology is working with NMFS, USFWS, WDFW, WSDA and EPA to have the aquatic permitting program protected from "Take" liability under the exemption provision of the ESA 4(d) rule. A pesticide/ESA technical group and a separate policy group, both comprised of representatives from these agencies, have been meeting to review the potential risks that permitted aquatic pesticides may pose to salmonids and evaluate whether the aquatic pesticide permitting program provides adequate protection for listed species.

However, the NMFS science center and USFWS staff's are satisfied that the seawater challenge tests indicate an appropriate margin of safety, and will likely support the permitted use of aquatic pesticides that pass this test. At present, acceptable seawater challenge information exists for Aquathol®, Hydrothol® 191, 2,4-D and Diquat. Seawater challenge tests have raised significant concerns regarding the use of copper compounds in salmonid waters. Product manufacturers will need to do these tests if they expect coverage.

Rare, Threatened or Endangered Plant Species. Herbicide treatments have the potential to affect submersed or submersed plant species listed by the federal government as rare, threatened, or endangered. These species may be aquatic or may occur along the banks of waterways. Applicators for short-term modifications to water quality standards for each specific site are required to include a review of "proposed sensitive" plants and animals listed by Washington State National Heritage Data System (see http://www.wa.gov/dnr/htdocs/fr/nhp/wanhp.html).

Water Quality Program Policy limits the use of copper in salmon-bearing waters. Given the known toxicity of copper compounds to aquatic life, primarily amphibians and fish, and given the recent ESA listings of several salmonid species in Washington State waters, in May 1999, Ecology's Water Quality Program made an interim policy decision to disallow the use of copper in salmon-bearing waters. This decision affects all waters of the state utilized by salmonids and will be revisited in the risk assessment exercise scheduled for copper compounds next year.

Irrigation Ditches. Herbicides are used throughout Washington State on the canals, laterals, drains, and waterways of irrigation systems to maintain flow velocity and capacity of the waterways that drain into various streams and rivers, including the Columbia River. Commonly used herbicides include 2,4-D, copper sulfate, acrolein, and xylene. Application practices vary somewhat but typically 2,4-D is applied to control terrestrial vegetation along canal and drain banks 1-2 times/year during the growing season. Irrigation districts usually apply copper sulfate to control filamentous green algae during the growing season. Copper sulfate may be applied every two weeks, generally to the laterals. Most districts use acrolein to control in-water vegetation (Weaver, 1999). Ecology allows these herbicides applications by letter to the irrigation districts but the districts have been encouraged to develop a separate EIS document for guidance for these applications. Diquat is not permitted for use in irrigation ditches.

4. Experimental Use Permits

Pesticides are allowed on an experimental use basis for purposes of research or in an emergency. Emergency situations can occur every year in Washington State, and they do take their economic toll. However, Section 18 of FIFRA, a provision that allows the EPA under emergency circumstances to temporarily exempt a pesticide from the full requirements of registration, is designed to specifically address these emergency situations. Because the state of Washington is one of the leading minor crop states in the nation and grows over 300 different commercial crops, we tend to have emergencies each year (Wheeler, WSDA, 2000, personal communication).

WSDA and Ecology have a concurrent process for issuing Experimental Use Permits for pesticides that are not federally registered for aquatic use. EPA uses these permits to accumulate information necessary to register a pesticide under Section 3 of FIFRA for aquatic use. A pesticide manufacturer must be working toward a Section 3-registration or state registration in order to be eligible for an EUP.

RCW 90.48.445 exempts small scale EUPs from SEPA, as defined in 40 CFR Section 172.3. When WSDA issues an experimental use permit (as authorized by RCW 15.58.405(3)), the exception from SEPA is limited to experiments of one surface acre or less (Substitute Senate Bill 5670, 1999). Experimental use under federal law for sites larger than one surface acre is still subject to SEPA review.

References

Agriculture, et al. 1999. Draft Environmental Assessment: Cooperative Gypsy Moth Eradication Project King and Pierce Counties Washington. Washington State Department of Agriculture, United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection Quarantine.

Battelle, Inc. 1997. An Evaluation of the Feasibility of Using Integrated Pest Management to Control Burrowing Shrimp in commercial Oyster Beds. Prepared for the Department of Ecology by Battelle Marine Sciences Laboratory, Sequim, WA.

Bottrell, D.R. 1979. Integrated Pest Management. Council on Environmental Quality. #041-011-00049-1, US Government Printing Office, Washington, D.C. 120 pp.

Ebasco Environmental, et.al. 1993. *Noxious Emergent Plant Management Environmental Impact Statement,* Washington State Department of Ecology's Water Quality Program, Olympia, Washington.

Ecology. 1999. Screening Survey of Carbaryl (Sevin TM) and 1-naphthol Concentrations in Willapa Bay Sediments. Washington State Department of Ecology. pp. 3.

Endangered and Threatened Species: Proposed Rule Governing Take of Seven Threatened Evolutionarily Significant Units (ESUs) of West Coast Salmonids. January 3, 2000. 170 Federal Register. Vol. 65, No. 1. Proposed Rules DEPARTMENT OF COMMERCE, National Oceanic and Atmospheric Administration, 50 CFR Part 223.

Endangered Species Act Status of Washington Salmon, Trout, and Steelhead Populations Present and Newly Expanded Regional Extent of ESA Listings, November 22, 1999. http://www.wa.gov/wdfw/hab/phspage.htm

Engrossed Second Substitute Senate Bill 5633, State of Washington, 54th Legislature, 1995.

Engrossed Substitute Senate Bill 5424, Washington State, 56th Legislature, May 10, 1999. http://www.leg.wa.gov/pub/billinfo/1999-00/senate/5400-5424/5424-s_sl_05131999.txt

EPA. 1997. Health and Environmental Effects Profile for Carbaryl. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, U.S. EPA, Cincinnati, OH. pp. 95.

Hardy, Joan F., Steven L. Saunders and Kari Rokstad. 1992. *Aquatic Plant Management Program's Final Supplemental Environmental Impact Statement*, Washington State Department of Ecology's Water Quality Program, Olympia, Washington.

Saunders, Stephen L. 2000. Personal communication and email communication, February 24 and April 11, 2000, Washington State Department of Ecology, Olympia, Washington.

Saunders, Stephen L.1992. State Programs for Aquatic Pesticide Regulation, Enhancing the State's Lake Programs, Washington State Department of Ecology, Olympia, Washington. 51-58 pp.

Smith, R.F., and R. van den Bosch. 1967. Integrated control. In, W.W. Kilgore and R.L. Doutt (eds.), Pest Control- biological, physical, and selected chemical methods. Academic, New York.

Stewart, N.E., R.E. Milleman and W.P. Breese. 1997. Acute Toxicity of the Insecticide Sevin and its Hydrolytic Product 1-naphthol to Some Marine Organism. Transactions of American Fisheries Society 96:25-30.

U.S. Department of Agriculture. 1995. Gypsy Moth Management in the United States: a cooperative approach. Final Environmental Impact Statement as Supplemented – 1995. USDA Animal and Plant Health Inspection Service and USDA Forest Service.

Vallentyne, J.R. 1974. The Algal Bowl-Lakes and Man. Ottawa, Misc. Special Pub. 22, Dept. of the Environment, 185 pp.

Washington State Department of Agriculture, et al. 1993. Environmental Impact Statement: Noxious Emergent Plant Management. Washington State Department of Agriculture, Washington State Department of Ecology, Washington State Department of Natural Resources, Washington State Department of Fisheries, Washington State Department of Wildlife, Washington State Noxious Weed Control Board.

Washington State Department of Ecology. 1980. Environmental Impact Statement: Aquatic Plant Management.

Washington State Department of Ecology. 1992. Final Supplemental Impact Statement and Responsiveness Summary (FIES): Aquatic Plants Management Program for Washington State.

Washington State Department of Ecology. 1999. Water Quality Program Policy: WQP Policy 1-6: Use of Short-Term Modifications for the Application of Aquatic Mosquito Control Insecticides.

Washington State Department of Ecology. 1999. Water Quality Program Procedure: WQP Procedure 1-6A: Short-Term Modifications for Aquatic Mosquito Control.

Weaver, Dewey. 1999. A Case Study Evaluating a Change to the Surface Water Quality Standards from "Class-based" to "Use-bases" within the Columbia Basin Project Area. Washington State Department of Ecology, pp. 6-8.

Wetzel, R.G. 1975. Limnology. W.B. Saunders Company. Philadelphia. 743 pp.

Wildlife. 1988. Draft Environmental Impact Statement: Lake and Stream Rehabilitation Program 1988-1989. Washington State Department of Fish and Wildlife.

Wheeler, Wendy Sue. Washington State Department of Agriculture. Personal Communication, December 5, 2000.

Section II. Alternative Aquatic Plant Management Methods

A. Introduction to Alternatives

Alternatives are defined in terms of actions that might be taken by an agency or agencies for aquatic plant management. The "action(s)" required to implement various aquatic plant management alternatives include state activities such as Ecology's issuance of short term modifications of water quality standards to allow rotovation, suction drudging or application of herbicides to waters of the state. Actions may also include Ecology's funding of lake restoration and freshwater aquatic plant management activities or WDFW issuance of permits allowing the use of grass carp and their issuance of Hydraulic Project Approval (HPAs) for hand pulling, raking, harvesting diver dredging, weed rollers, rotovation and bottom barrier installation. Local governments may require shoreline permits for mechanical or chemical treatment projects or projects costing over $2,500. The U.S. Army Corp of Engineers may also require Section 404 permits for suction dredging and rotovation projects. For simplicity, the term "permits" is used when referring collectively to all of these permits.

The Proposed Action that triggered this SEPA action is the request to use new herbicides and to update our permitted use of currently permitted herbicides where significant research or information has been developed since the 2001 SEIS. 2,4-D, Aquathol and Hydrothol 191 were evaluated in year 2000, diquat in 2002 and triclopyr and glyphosate are expected to be evaluated in 2003. When the first Aquatic Plant Management EIS was developed in 1980, Ecology determined that applications of herbicides are likely to result in significant adverse environmental impacts, thus creating the need to develop an Environmental Impact Statement (EIS). The evaluation of diquat adds information and analysis to supplement the 1980 and subsequent 1992 and 2001 Aquatic Plant Management Environmental Impact Statements.

The SEPA EIS process is used to identify and analyze probable adverse environmental impacts, reasonable alternatives, and possible mitigation. The EIS process provides public participation in developing and analyzing information and improves the proposals through mitigation of identified adverse environmental impacts and development of reasonable alternatives that meet the objective of the proposal. It also gives agencies the authority to condition or deny a proposal based on the agency's adopted SEPA policies and environmental impacts identified in a SEPA document (RCW 43.21C.060, WAC 197-11-660).

This SEIS discusses five alternatives for controlling aquatic plants. Along with the evaluation of diquat in the chemical methods only section, the information on integrated, biological, mechanical and manual methods of aquatic vegetation control are included. However, the update of those sections has been largely cursory due to lack of funding and time. The integrated pest management (IPM) method is included to assure the use of integrated management methods as required by the 1997 Integrated Pest Management (IPM) Law (Chapter 17.15 RCW). Coverage for permit applications for herbicide treatments are almost always submitted for a one-year period, with Ecology receiving the same herbicide applications for the same water bodies year after year. With a long-term planning requirement, this may change. The planning addition also takes advantage of the 1997 changes to the WQS (WAC 173-201A-110) which enables Ecology to authorize three to five year permits under certain conditions. ESA issues and the development of biological control methods are also changing the permitting process and these changes are further discussed in the Preferred Alternative Section.

When using a three to five year integrated management approach, all of the alternative control methods may have an optimal time and place for use with respect to environmental concerns and efficacy of control. However, absent certain precautions, adverse environmental impacts may result from any control method. For this reason, the principle features and mitigation measures for each alternative are discussed in detail at the end of their respective sections. The information provided is intended to aid decision-makers in assessing available alternatives and their appropriate application. The alternatives evaluated are:

1. Use of an integrated management approach (the preferred alternative),
2. The "no action" alternative, which means continuing current practices,
3. Use of mechanical/manual methods only,
4. Use of biological methods only, and
5. Use of chemical methods only (the proposed actions).

B. Analysis and Comparison of Alternatives

State surface water quality regulations and standards (RCW 90.48; Chapter 173-201A WAC) provide authority to establish criteria for waters of the state and to regulate various activities, including those related to aquatic plant control. These standards articulate an intent to protect public health and maintain the beneficial uses of surface waters, which include recreational activities such as swimming, SCUBA diving, water skiing, boating and fishing and aesthetic enjoyment; public water supply; stock watering; fish and shellfish rearing, spawning, and harvesting; wildlife habitat, and commerce and navigation. *A short-term modification of water quality standards (permit) cannot be issued if water quality degradation interferes with or becomes injurious to existing water uses and causes long-term harm to the environment.*

Key to the analysis and comparison of alternatives is the state's goal to maintain beneficial uses of state waters and protect the environment. Therefore each method will be evaluated for:

1. The extent the alternative detracts from the beneficial use of a particular water body;
2. Potential adverse environmental impacts, especially regarding ESA listed species and wetlands;
3. Potential adverse human health impacts; and

4. The degree to which any one method effectively controls a particular plant problem, especially those aquatic plants designated as noxious or invasive.

Because of the complexity and variability of water bodies, their beneficial uses and the types of management needed, specific evaluation of impacts and mitigation will have to be applied on a case-by-case basis to various management proposals. To assist in this assessment, each method and each herbicide allowed for use will be assessed with the above criteria. If adverse environmental impacts cannot be avoided by the use of any one method or herbicide, its use may be restricted or disallowed.

In the sections on various methods of aquatic plant management, and for each herbicide assessed by this Supplemental Environmental Impact Statement, elements of the environment (WAC 197-11-444) that may be significantly affected are discussed. Since lakes are the primary environments where methods of aquatic plant control will be applied, only those elements that pertain to lakes, ponds or streams and their beneficial uses are included in the assessment.

C. Mitigation Defined

As defined by SEPA, mitigation means, in the following order of preference:

1. Avoiding the impact altogether by not taking a certain action or part of an action;
2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;
3. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of an action; and
5. Compensation for the impact by replacing, enhancing, or providing substitute resources or environments.

When evaluating potential impacts to aquatic habitat, the following definition shall be used: wildlife habitat means waters of the state used by, or that directly or indirectly provide food support to fish, other aquatic life and wildlife for any life history stage or activity.

D. ESA Considerations for all Methods

Several salmon populations and other aquatic biota are listed for special protection under ESA. Such listings may affect aquatic control projects all over Washington State. Information regarding potential listings of endangered species in particular water bodies can be obtained from the local office of WDFW.

Obtaining a permit from Ecology for the application of herbicides does not exempt an applicator from “Take” liability under ESA. Applications that are made outside the permitting process, such as the 2,4-D applications being made under SSB 5424, or in irrigation ditches are also not exempt from potential take liability. “Take” means to “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in such conduct” with respect to a species listed under ESA (16 U.S.C. Section 1532(19)). Current permit applications require applicators to state whether the proposed treatment area is part of any designated critical habitat of an ESA listed species or an Evolutionary Significant Unit listed under ESA. Proposed treatments that may have an adverse impact on a listed species may be denied a permit or restricted.

Rare, Threatened or Endangered Plant Species Treatments with herbicides have the potential to affect submersed or emergent plant species listed by the federal government as rare, threatened, or endangered. These species may be aquatic or may occur along the banks of waterways. Applications for short-term modifications to water quality standards for each specific site should include a review of "proposed sensitive" plants and animals listed by Washington State National Heritage Data System. Check for plant listings at http://www.wa.gov/dnr/htdocs/fr/nhp/wanhp.html .

E. Wetlands: Mitigation for All Methods

Definitions. Evaluation of potential adverse impacts to non-target wetlands from aquatic plant control will be determined using the following definitions.

1. "Wetlands" means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, such as swamps, marshes, bogs, and similar areas. This includes wetlands created, restored or enhanced as part of a mitigation procedure. This does not include constructed wetlands or the following surface waters of the state intentionally constructed from non-wetland sites: Irrigation and drainage ditches, grass-lined swales, canals, agricultural detention facilities, farm ponds, and landscape amenities.
2. "Constructed wetlands" means those wetlands intentionally constructed on non-wetland sites for the sole purpose of wastewater or storm water treatment and managed as such. Constructed wetlands are normally considered as part of the collection and treatment system.
3. "Created wetlands," means those wetlands intentionally created from non-wetland sites to produce or replace natural wetland habitat.
4. "Drainage ditch," means that portion of a designed and constructed conveyance system that serves the purpose of transporting surplus water.
5. "Irrigation ditch means that portion of a designed and constructed conveyance facility that serves the purpose of transporting irrigation water from its supply source to it place of use.

The following provides guidance for decisions regarding wetlands mitigation:

".... The overall goal of mitigation shall be no net loss of wetland function and acreage. Where practicable, improvement of wetland quality should be encouraged" (Executive Order 89-10).

1. Water quality in exceptional wetlands shall be maintained and protected. Exceptional wetlands are those determined by Ecology to meet one of the following criteria:
    - Wetlands that are determined by the Department of Natural Resources to meet the criteria of the Washington Natural Heritage Program as specified in Chapter 79.70 RCW:
    - Mapped occurrence of threatened and endangered species and their priority habitats as determined by WDFW:
    - Documented critical habitat for threatened or endangered species of native anadromous fish populations as determined by WDFW:
    - Designated outstanding resource waters. and
    - High quality, regionally rare wetland communities with irreplaceable ecological functions, including sphagnum bogs and fens, marl fens, estuarine wetlands and mature forested swamps.

2. Water quality in all other wetlands shall be maintained and protected unless it can be shown that the impact is unavoidable and necessary. Avoidance shall be the primary means to achieve the water quality goals of this chapter. For water-dependent activities, unavoidable and necessary water quality impacts can be demonstrated where there are no practicable alternatives that would:
    - Not involve a wetland or that would have less adverse water quality impacts on a wetland;
    - Not have other more significant adverse consequences to the environment or human health.

3. When it has been determined that lowering the water quality of a wetland is unavoidable and necessary and has been minimized to the maximum extent practicable, wetland losses and degradation shall be offset, where appropriate and practicable, through deliberate restoration, creation, or enhancement of wetlands.
    - In-kind replacement of functional values shall be provided, unless it is found that in-kind replacement is not feasible or practical due to the characteristics of the existing wetland and a

greater benefit can be demonstrated by an alternative. In such cases, substitute resources of equal or greater ecological value shall be provided.

- On-site replacement shall be provided, unless it is found that on-site replacement is not feasible or practical due to physical features of the property or a greater benefit can be demonstrated by using an alternative site. In such cases, replacement shall occur within the same watershed and proximity.
- A mitigation plan shall be required for proposed mitigation projects. Elements that may be required in a mitigation plan include:
  a. A description of the impact or damage that is being mitigated.
  b. A description of the mitigation site,
  c. A discussion of the goals of the mitigation, e.g., restoring a native plant community, enhancing the wildlife habitat values by diversifying vegetation, replacing native aquatic vertebrates, etc.
  d. A description of actions being taken, e.g., planting, habitat enhancement, re-stocking, etc.,
  e. Performance measures by which achievement of the goals can be assessed (e.g. providing an acre of wetland habitat, vegetated with at least 30% cover of native aquatic bed vegetation within 3 years, or successful breeding of three species of native amphibians)", and
  f. A monitoring plan to determine if the actions achieve the goals and performance standards.
- Restoration, enhancement, or replacement shall be completed prior to wetland degradation, where possible. In all other cases, restoration, enhancement, or replacement shall be completed prior to use or occupancy of the activity or development, or immediately after activities that will temporarily disturb wetlands.

F. Mitigation for Sediment for All Methods

The Sediment Management Standards, Chapter 173-204 WAC, have a narrative standard of *no effect*, which applies to all sediments (Washington 1995a.). To the extent that herbicides or other control methods may have adverse effects on benthic organisms, permit writers can require a sediment mixing zone, i.e., a sediment impact zone or consider the proposed action unacceptable pursuant to anti-degradation policy (Chapter 173-201A-070 WAC).

Sediments are a fertile repository for pollutants, as explained in the following excerpt from *Bioassessment Analysis of Steilacoom Lake Sediments*:

> The assessment of adverse effects of contaminated sediment on fish and invertebrate populations exists as a major problem for aquatic toxicologists. Contaminant material generally precipitates, forms various complexes or adsorbs and binds to particulate matter (Giesy et.al., 1990). Ultimately, sediment serves as the final repository for the pollutant. Benthic organisms can be directly impacted via the ingestion of particulate matter or continual re-exposure due to leaching and re-suspension of contaminant material resulting from physical disturbances to the sediment (Geisy et.al., 1988). Bioavailability of sediment contaminants depends on many factors, including physical properties of the sediment and the contaminant and physical and biological properties of overlying water. Water quality criteria are based on the concentration of a particular substance in solution in the water column. Sediment criteria have only recently begun to be established (Henry et.al. 1991).

The anti-degradation and designated use policies of the Sediment Management Standards (Chapter 173-204-120 WAC) state, in part, that *existing beneficial uses must be maintained and that sediment must not be degraded to the point of becoming injurious to beneficial uses*. Additionally, sediment in waters considered outstanding natural resources must not be degraded; outstanding waters include those of national and state parks and scenic and recreation areas, wildlife refuges, and waters of exceptional recreational or ecological significance. The purpose of the standards is to manage pollutant discharges and sediment quality to protect beneficial uses and move towards attaining designated beneficial uses as specified in section 101(a)(2) of the Federal Clean Water Act (33 USC 1251, et. seq.) and Chapter 173-201A WAC, the State's surface water standards.

The sediment standards include specific marine-sediment chemical criteria, but the criteria for low salinity and freshwater sediments have not yet been developed (Chapter 173-204-100(2) WAC).

References

Washington State Department of Ecology. 1995a. Sediment Management Standards, Chapter 173-204 WAC.

Henry, M.G., Morse, S. and Jaschke, D. 1991. Minnesota Cooperative Fish and Wildlife Research Unit

Executive Order EO 89-10, 1989. http://www.governor.wa.gov/eo/eoarchive/eo89-10.htm

Section III. The Preferred Alternative: An Integrated Aquatic Vegetation Management Plan

A. Documents and References for Developing an Integrated Aquatic Plant Management Plan

The current preferred alternative is based on the 1992 Final Supplemental Environmental Impact Statement (FSEIS) and includes new guidance from:

- *A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans* (1994),
- The 1997 Integrated Pest Management (IPM) Law (Chapter 17.15 RCW), and
- The 1997 changes to the WQS (WAC 173-201A-110).

Integrated aquatic plant management planning has already been implemented with some success. At least a dozen plans have been written to address various nuisance or noxious weed problems in lakes in Washington. Ecology continues to actively urge lake groups that chemically treat their lakes regularly to develop an integrated aquatic plant management plan before they apply for future aquatic herbicide permits. Ecology recognizes there is no one-size-fits-all planning method and recommends an appropriate level of planning be used when applying for chemical/aquatic plant control permits.

- Watershed planning is the broadest, most inclusive planning method and is probably most appropriate for use by governmental entities and other large groups able to secure grants or other funding for the plan.
- Lake Management planning is a somewhat reduced scale of watershed planning but still contains some critical components of the larger plan. Typically lake management groups and other, small-scale groups may consider this level of planning for aquatic plant control.
- Lastly, individuals or small groups with limited resources may consider integrated aquatic plant management planning on a scale that fits their needs. This last type of planning would still incorporate critical components of the other two methods, but would be doable for small-scale management operations.

The level of planning needed may also be based on the size or percentage of the waterbody to be treated. It is our intention to provide flexibility in our guidance, review and approval of such plans and in the permitting process.

Like the 1992 preferred alternative, Ecology's 1994 guidance manual and the IPM law recommend consideration of all available methods in an integrated aquatic plant management plan. Under this alternative, each lake or surface water system is evaluated to determine the extent and underlying causes of aquatic plant and/or algae problems and the most effective and environmentally sound control strategy for correction and long-term management. Using the best combination of biological, mechanical, and physical control methods may eliminate the need for further action against many nuisance aquatic plants. When the nuisance plant species can not be controlled with non-chemical methods at a level adequate to support the prioritized beneficial uses, the addition of chemical control methods to the management strategy may be necessary or desirable, especially when targeting noxious species. This current supplement to the EIS looks at the chemical diquat as an additional tool for aquatic plant management. However, when chemicals are added to a management strategy, the selection of the herbicide, dosage, and treatment time must be carefully coordinated to avoid ecological disruptions.

In general, integrated management is the selection, integration, and implementation of control methods based on predicted economic, ecological, and sociological consequences. This concept is based on the premise that, in many cases, no single control method will by itself be totally successful. Thus, a variety of biological, physical, and chemical control and habitat modification techniques are integrated into a cohesive plan developed to provide long-term vegetation control (Bottrell 1979). Integrated management may include various land-use practices necessary to reduce or eliminate the introduction of nutrients and sediments causing accelerated aquatic plant and/or algae growth. The ultimate objective is to control detrimental vegetation in an economically efficient and environmentally sound manner.

The IPM Law, Chapter 17.15 RCW, defines the elements of integrated pest management to include:

> (a) Preventing pest problems,
> (b) Monitoring for the presence of pests and pest damage,
> (c) Establishing the density of the pest population, that may be set at zero, that can be tolerated or correlated with a damage level sufficient to warrant treatment of the problem based on health, public safety, economic, or aesthetic thresholds;
> (d) Treating pest problems to reduce populations below those levels established by damage thresholds using strategies that may include biological, cultural, mechanical, and chemical control methods and that must consider human health, ecological impact, feasibility, and cost-effectiveness; and
> (e) Evaluating the effects and efficacy of pest treatments.
> (2) "Pest" means, but is not limited to, any insect, rodent, nematode, snail, slug, weed, and any form of plant or animal life or virus, except virus, bacteria, or other microorganisms on or in a living person or other animal or in or on processed food or beverages or pharmaceuticals, which is normally considered to be a pest, or which the director of the department of agriculture may declare to be a pest.

Typically, this approach would not be used for one-season treatments but would rather be the basis for three to five-year aquatic plant management strategies. A key use of a plan would be its development and assimilation into the permit process as provided by WAC 173-201A-110 (1)(c). Ideally, the permit would provide guidance and consistency for balancing various beneficial uses and control methods for each aquatic system. Each plan would be developed through a public involvement process consistent with SEPA and the Administrative Procedure Act (Chapter 34.05 RCW) that includes state and local resource agencies, Indian tribes, user groups and the public. Proposed integrated management planning should be set up so that affected communities and interest groups can review and comment on proposed management strategies where potentially conflicting uses in a given water body exists. Plans would be used to help lake managers and permit writers evaluate whether plants that provide fisheries or wildlife habitat should be eradicated to improve aesthetics or recreational use of a waterbody. Resource agencies would be asked to participate in plan development and review. These agencies, including Ecology, would have to ensure consistency of plans with agency goals, policies, and regulations and each plan would be subject to Ecology's review and approval before use in the permitting process.

B. Guidelines for Developing an Integrated Aquatic Vegetation Management Plan

Some of Ecology's regional offices have developed guidance materials; those materials are available upon request. As previously mentioned, an illustrated manual entitled *A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans* (IAVMP Manual) is available for the development of a watershed, lake or an integrated aquatic vegetation management plan (Gibbons, 1994). The IAVMP

Manual, dated January 1994, was written to assist citizens and lake management groups to develop IPM plans. The manual (about 40 pages not including the appendices) is available on Ecology WebPages at: http://www.ecy.wa.gov/programs/wq/links/plants.html or a copy may be obtained from Ecology's publication office at (360) 407-7472.

A sample integrated aquatic vegetation management plan, developed for Lake Leland, is also available on Ecology's website at: http://www.ecy.wa.gov/programs/wq/links/plants.html. The IAVMP Manual and the sample plan specifically address controlling nuisance aquatic plants and provide guidance for aquatic plant managers. Aquatic plant managers are those individuals and entities interested in or responsible for sponsoring and/or providing oversight for aquatic treatments designed to control nuisance aquatic pests. Funding may be available for the development of integrated aquatic vegetation plans through Ecology's Aquatic Weeds Program. Funding is for government entities, tribes or special purpose districts to be used on waterbodies with public boat ramps. Noxious weed projects receive funding priority. For more information see: http://www.ecy.wa.gov/programs/wq/links/plants.html . The following is a summary of the IAVMP Manual guidance.

Identify the aquatic plant targeted for control

The first step in preparing a plan is the development of a problem statement. The problem statement considers the users of the waterbody and what they consider to be the problem. Those problems can be grouped into categories and condensed into a problem statement.

Aquatic plant communities vary at least as much as the human and wildlife communities that use them, necessitating the consideration of many factors for potential aquatic plant managers, such as:

- Is there an aquatic plant problem?
- What is the problem?
- Should anything be done about it?
- Should a community group be formed to address the problems?
- Who will participate in the planning process?

Depending on a water body's size, depth, and other characteristics, aquatic plant growth can be extensive or occur in small-localized areas. In order to design an effective management program specific to your water body, the types of aquatic plants growing there, their location and the extent of growth must first be determined. This can be accomplished by performing an aquatic plant survey. A survey involves systematically traveling around the water body and shoreline and noting aquatic plant conditions. An important part of the survey is collecting samples of aquatic plants to verify the species. This is especially important if invasive, nonnative aquatic plants are suspected to be present.

Once the aquatic plants are mapped, the next step is to use that information to write a description of beneficial and problem plant zones. Characterizing the aquatic plant zones helps to determine where special control actions are required and consists of the following tasks:

1. Describe Plant Types
2. Determine Problem Areas and Beneficial Plant Zones
3. Determine Need for Special Action

Control and/or eradication of aquatic species listed as noxious are considered more critical than control of non-noxious species. The Washington State Noxious Weed Board designates certain aquatic plants as noxious. None of the weeds on the Washington State Noxious Weed List are native to the state. Every year, the Board adopts, by rule, a noxious weed list. The list determines which plants will be considered noxious weeds and where in Washington control will be required. Noxious weeds are divided into classes (Class A, B, or C), depending for the most part on the extent of distribution within Washington.

- Class A species are those noxious weeds not native to the state that are of limited distribution or are unrecorded in the state and that pose a serious threat to the state,
- Class B species consists of those noxious weeds not native to the state that are of limited distribution or are unrecorded in a region of the state and that pose a serious threat to that region,
- Class C species have populated the state to such an extent that containment may not be practical.

This approach classifies non-native plants that have the potential to cause serious problems because they are invasive and/or are a threat to natural resources such as native-plant communities, wetlands, rangeland, or cropland. An integrated aquatic plant management approach recognizes the need for a strategy of total eradication under special circumstances. In some cases, impacts and potential impacts from noxious or invasive non-native species may outweigh impacts and potential impacts from treatment.

Requirements for control are region-specific and based on the economic and environmental feasibility for effective control along with the seriousness of problems presented by the noxious species. The fact that control is required and enforced should be considered an indication of the feasibility of control in addition to the seriousness of the problem presented by a noxious weed. Noxious plant species that have been identified are on the State Noxious Weed List (Chapter 16-750 WAC and can be found at (http://www.wa.gov/agr/weedboard/index.html).

Public Involvement and Education

Once an aquatic-plant growth problem has been recognized, it is crucial to bring all interested and affected parties together early on to participate in planning. Identifying people who have an interest in the water body often requires a bit of searching. The water body may serve a variety of groups with sometimes-conflicting interests. State, county or local governments and agencies may be involved. Private businesses or other interest groups may have concerns about the water body as well. Some groups that may have an interest in management of an aquatic system are:

- Residents or property owners around the water body
- Special user groups (e.g., bass anglers, Ducks Unlimited)
- Local government
- State and federal agencies (e.g., State Department of Ecology)
- Native American tribes
- Water-related businesses (e.g., resorts, tackle & bait shops, dive shops)
- Elected officials
- Environmental groups (e.g., Audubon).

Certainly every effort should be made to bring as many interested parties to the table as possible. However, it may be difficult and costly for an individual shoreline owner or other small groups interested in aquatic plant management to identify and contact potentially interested groups, conduct public meetings and keep the community informed. Fortunately, if a plan is to be incorporated into a long-term permit, a public involvement process consistent with SEPA and the Administrative Procedure Act (Chapter 34.05 RCW) is already in place that solicits involvement from state and local resource agencies, Indian tribes, user groups and the public. Conceivably, potential aquatic pest managers may elect to have their plans developed in conjunction with their permits for this reason.

Applications for aquatic plant control permit coverage are forwarded for SEPA review and comment to other interested entities (WSDA, WDFW, DNR, tribes, local governments, other Ecology offices and programs, and interest groups), initiating a thirty day comment period. Comments received are included in the official permit record, and Ecology prepares a response to comments explaining its acceptance of the permit coverage.

State a Management Objective in Support of Beneficial Uses

Beneficial uses of water bodies are protected by Washington State statute. Under the State Surface Water Quality Standards (Chapter 173-201A WAC), protected beneficial uses include fish and shellfish rearing; spawning and harvesting; swimming; boating; navigation; irrigation; wildlife habitat; and domestic, industrial, and agricultural water supply.

Desired uses of a water body must be compatible with its capacity to sustain those uses, both human and natural. Unfortunately, a single water body often supports many different desirable uses, which sometimes conflict with each other. The management challenge involves identifying and agreeing on uses that complement each other, and realistically managing for these uses. Common use areas include:

- Conservancy areas, including habitats that are integral to the lake ecosystem, such as nesting sites, fish rearing or spawning areas, or locations of rare plant communities.
- Boating and boat access areas (launches, ramps)
- Water skiing zones
- Beaches and swimming areas (public, private)
- Fishing areas
- Areas for special aquatic events (e.g., sailing, rowing, mini hydroplane races)
- Parks, picnic areas, nature trails, scenic overlooks
- Irrigation/water supply intakes
- Other shoreline uses (e.g., residential, commercial).

Lakes are eco-systems that provide habitat for fish, wildlife and aquatic plants. The plan to control aquatic plants and algae should consider what the lake would naturally support in a pre-development stage. Then a decision should be made on how much control is desired. Should the algae and plant populations be:

- Kept the same as present conditions,
- Returned to a 'natural' pre-development condition, if possible,
- Managed to allow beneficial uses of a waterbody, or
- Controlled beyond what the lake would naturally support and to what extent?

Under the alternatives to restore or control beyond restored conditions, each lake system is evaluated to determine the extent and underlying causes of aquatic plant problems. Then, the most effective and environmentally sound control strategy can be implemented. The following points should be considered in developing a management objective.

1. The ecosystem is the management unit and the entire watershed should be managed as a natural ecosystem or if needed, restored to a natural system. Even subtle manipulations may affect the ecosystem, possibly aggravating one problem in attempt to resolve another. System disruptions should be avoided, and problem vegetation held to a tolerable level. However, the goal for species designated as noxious would be total eradication, maintenance at low levels, or containment.

2. Any technique, or combination of techniques, must be carefully considered in an ecological context before and after use of aquatic plant or algae control. As demonstrated in the impact analysis sections of this SEIS, most alternatives have the potential to cause some level of adverse environmental impacts.

3. Integrated management requires review of each waterbody using an interdisciplinary approach. When determining if there is an aquatic plant/algae problem and before deciding how to solve a particular plant-management problem, the waterbody should be evaluated from several perspectives. This may require

identification of the cause of suspected excessive plant and/or algae growth including: sources of nutrient loading, an analysis of water and sediment quality, an assessment of beneficial uses provided by the water body, and identification of any wetlands or other sensitive ecosystem in the area. Proposals should be reviewed by a variety of experts or agencies that specialize in different fields of lake management. Special interest groups and waterbody users would also be involved in this evaluation.

4. A "risk" threshold should be established to help determine if plants proposed for eradication are truly problematic. Though dozens of plant species may exist in a given waterbody, only a few may present major problems in any one location. The threshold would be used to determine if, and the degree to which, an aquatic plant should be controlled, contained, or maintained at low levels. (Also see Chapter 17.15 RCW (c), of the IPM law.)

Ecology as well as private contractors provide information about waterbody management planning or other aspects of aquatic plant management. This includes lectures or participation in conferences designed for herbicide applicators, lake management associations and districts, weed control boards, resource agencies, academicians or others that may be interested in, or affected by, aquatic plant management efforts. WebPages on aquatic plants and lake issues are maintained by Ecology at: http://www.ecy.wa.gov/programs/wq/links/plants.html . Information about management methods, noxious weeds, native plants, plant identification, financial assistance for weed management projects, and general information about lakes is available at this site. Publications about noxious aquatic weeds are also available from Ecology's Publication Office at (360) 407- 7472.

After management objectives for the water body are determined, the physical characteristics of the water body must be assessed for prevention and restoration opportunities.

Prevention and Lake Restoration Opportunities

A lake or river is a dynamic, living system, teeming with physical, chemical and biological activity. The system extends beyond its shores to include surrounding land whose waters drain into the water body (the watershed). A water body and its watershed are inseparable. In fact, water body conditions are very much influenced by what occurs in the watershed. For instance, a watershed contributes nutrients to a water body that are necessary for aquatic plant growth. These nutrients—especially phosphorus and nitrogen—flow to the lake from all parts of the watershed by way of streams, ground water, and stormwater runoff. In addition, activities in the watershed, such as agriculture and forestry, road maintenance and construction can all contribute silt, debris, chemicals, and other pollutants to the waterbody.

A plan should consider these possible sources of nutrient inputs and identify long-term measures to reduce them. Controlling watershed inputs from these sources can potentially enhance the effectiveness of primary in-lake control measures. Therefore this planning step is composed of two tasks:

1. Describing the watershed, including characteristics such as:
   - Size and boundaries of the watershed
   - Tributaries, wetlands and sensitive areas
   - Land use activities in the watershed
   - Nonpoint pollutant sources
   - Existing watershed management, monitoring or enhancement programs
   - The presence of rare, endangered or sensitive animals and plants

2. Describing the waterbody. Waterbody features that are important to identify are:
   - Location

- Size, shape, and depth
- Water sources
- Physical and chemical characteristics (water quality)
- Biological characteristics (animals and plants)
- Shoreline uses
- Outlet control and water rights.

Maps of the watershed and the waterbody should be included in the descriptions. Much of this information is readily available in county Growth Management Act (GMA) or other planning documents, maps or data that can be obtained from local planning or public works departments and state agencies. Check with the local WDFW office for ESA species of concern.

Preventing algae and aquatic plant problems includes preventing the introduction of noxious species, promoting eradication of noxious species to keep them from spreading to new areas, and improving water quality. The first goal, preventing introduction of noxious species, is achieved through efforts by Agriculture's quarantine program, Ecology's freshwater aquatic weeds program, developing a state Aquatic Nuisance Species Plan or developing some level of an integrated aquatic plant management plan. Eradication of some noxious species from a waterbody may be possible using a combination of aquatic plant control methods, and is further discussed in Ecology's "Washington's Water Quality Management Plan to Control Nonpoint Source Pollution" (2000). An overview of prevention techniques available for improving water quality is also summarized in the Nonpoint Source Pollution Plan. The Plan describes a holistic approach to controlling and cleaning up nonpoint source pollution, including lake restoration activities, which may be appropriate for large-scale watershed planning activities.

After management objectives for a waterbody are determined and the physical characteristics of the water body are known, control methods can be determined for a management plan.

Identify Control Methods

At this time, choices available for aquatic plant control include manual and mechanical methods, biological methods, and chemical methods. All are reviewed in this document or are discussed in the IVAMP Manual and on Ecology WebPages. As discussed above, a decision to use one or more methods would be based on potential environmental impacts, available mitigation, the amount and type of vegetation to be removed, and many other factors. In most cases, achieving control of aquatic plants without use of herbicides is preferred, particularly where target populations are small and manual methods or bottom barriers are a practical alternative.

Management strategies may involve a mix of methods. For example, for some waterbodies it may be best in the long term to develop a Eurasian water milfoil strategy designed to eradicate rather than control the species. The goal of eradication would be to eliminate the species from a system and may require measures more extreme than would be required for control. However, all large-scale control strategies that require repeat treatments may, over time, result in impacts that exceed those associated with eradication. An eradication program may include mechanical harvesting to reduce biomass, treatment with herbicides to achieve eradication, and if required, follow-up “spot” treatments that may include a combination of methods, including hand pulling, diver dredging, or spot application of aquatic herbicides.

Control intensity also needs to be specified. Are there plant zones around the lake that should be left alone (**no control**)? Where should a **low level of control** be applied to preserve some intermediate level of plant growth? And under what circumstances would a **high level of control** be necessary, such as where a minimal amount of nuisance plants can be tolerated (i.e. public swimming beaches).

And finally, a plan for monitoring the effectiveness and impacts of various control methods at selected sites on selected species must be incorporated into the integrated treatment plan. Before and after pictures as well as water samples and plant surveys are ideal tools for assessing the effectiveness of the chosen integrated treatment plan.

Choosing an integrated treatment scenario

This step involves choosing the combination of control efforts that best meets the needs of waterbody users with the least impacts to the environment. The procedure consists of evaluating each control option available using an **integrated vegetation management approach**. This approach involves examining the alternatives with regard to such factors as:

- The extent of problem plant(s) infestation
- Scale, intensity, and timing of treatment effectiveness against target plant(s),
- Duration of control (short-term vs. long-term)
- Human health concerns
- Environmental impacts and mitigation, if needed
- Program costs
- Permit requirements (federal, state, local).

Reviewing control alternatives in light of these and other site-specific factors provides a means of narrowing the options into an appropriate management package. This SEIS contains information on the impacts and mitigation requirements for each proposed method and those sections which describe the chosen methods should be carefully considered. No management program, however, is without some impacts. Choosing a management program will require weighing all the factors. The trick in deciding a course of action is to achieve a **balance** between expected management goals at a reasonable cost and acceptable environmental disruption.

Further discussion of how to develop an integrated aquatic plant management is provided in the IAVMP Manual. Once a plan is developed it may be included in an application for a Short-term Water Quality Modification (Permit) and submitted to Ecology for processing. If an Ecology permit will not be needed to implement the actions in the plan, the final task is to take all the information and formulate a **long-term action program (plan**) for aquatic plant management. This Plan provides the community with guidance and direction for aquatic plant management. The decision to proceed with aquatic plant control in the waterbody is just the beginning. Follow-through is critical. **Aquatic plant control is an ongoing concern that requires long-term commitment.** This is particularly true of water bodies with exotic plants or with nuisance plant growth that has developed over many years. In these situations, achieving management goals could take many years. The Plan should be flexible and evolving. It should provide for regular checking of how well the actions are working and allow for modification as conditions change.

C. Impacts and Mitigation

The impact of aquatic plant control methods selected for use, including the impact of removal of targeted species, must be assessed in terms of impacts on the particular ecosystem. This is a significant requirement in that the manipulation of an ecosystem may aggravate some pest problems while managing other pest populations. As demonstrated in the impact analysis section of this Final SEIS, most alternatives have the potential to cause some level of adverse environmental impacts. Even subtle manipulations may affect the ecosystem, possibly aggravating one problem in attempt to resolve another. Integrated management manipulates ecosystems to hold nuisance vegetation to tolerable levels while avoiding disruptions of the systems (Smith and van den Bosch 1967). Thus, all proposed techniques, or combination of techniques, must be carefully considered in an ecological context before and after use of aquatic plant controls. To do this a plan for monitoring the effectiveness and impacts of various control methods at selected sites on selected species must be developed. And finally, the section on each method also contains respective mitigation measures that may apply. These measures must also be included in the final plan, and the monitoring requirements and whatever mitigation measures are needed will be incorporated, when appropriate, into the conditions of the permit or the final action plan.

References

Bottrell, D.R. 1979. Integrated Pest Management. Council on Environmental Quality. #041-011-00049-1, US Government Printing Office, Washington, D.C. 120 pp.

Cooke, G.D, E.B. Welch, S.A. Peterson and P.R. Newroth. "Lake and Reservoir Restoration." Boston: Butterworths, 1986.

Gibbons, Maribeth V., Harry L. Gibbons, Jr., Mark D. Sytsma. Illustrated by Ruth Gothenquist. 1994. *A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans,* WATER Environmental Services, Inc. Ecology Publication 93-93. Also available at: http://www.ecy.wa.gov/programs/wq/links/plants.html

Washington State Department of Ecology, Water Quality Program. April 2000. *Washington's Water Quality Management Plan to Control Nonpoint Source Pollution*, Publication Number 9926. Also available at: http://www.ecy.wa.gov/biblio/9912.html

Section IV. The No Action Alternative: Continuing Current Practices

A. Description of the No Action Alternative

In the broadest sense, the no action alternative means that Ecology would continue to regulate water for aquatic plant control as we have since 1992. Ecology would continue to participate in lake restoration activities such as aeration, dilution, lake level regulation, and watershed controls and continue funding freshwater aquatic plant management activities through the Aquatic Weed Management Fund.

If new or "improved" aquatic vegetation control herbicides are not assessed and subsequently not permitted, opportunities to have new herbicide formulations for aquatic plant control that may be less harmful to the environment and humans and that are less costly would not be available to Washington State citizens.

The Washington Legislature directed Ecology to expand certain chemical application sections of the 1992 SEIS to make it more responsive for the application of new, commercially available herbicides, and to evaluate their use with the most recent research available (Engrossed Substitute Senate Bill 5424, effective May 10, 1999). If Ecology simply continued current practices, it could find itself at odds with a legislative directive.

B. Potential Impacts and Mitigation under Continuing Current Practices

Currently, permit coverages are issued for certain federal and state registered aquatic herbicides. In 2001, Ecology received water quality modification applications for the following herbicides:

copper compounds (including Komeen, Copper Sulfate, and AV-70);
glyphosate (Rodeo),
fluridone (Sonar),
endothall (Aquathol K),
endothall (Hydrothol 191) – experimental use,
diquat dibromide (diquat) – experimental use,
2,4-D ester (Aqua-Kleen) – legislative allowance
triclopyr (Renovate) – experimental use
Gallant – experimental use
Fusilade – experimental use
clethodim (Select) – experimental use
imazapyr (Arsenal) – experimental use

Before issuing permits, proposals are evaluated relative to their impact on human health, unique ecosystems, potable and irrigation water supply, fish, wildlife, navigation, hydropower, and other beneficial uses of state waters. Permits issued contain conditions designed to protect the environment and human health. Categories of conditions include, but are not limited to:

- Buffers, including restrictions on timing, distance, and chemical application rates,
- Notification requirements,
- Regulatory compliance, including compliance with the herbicide label and all applicable local, state, and federal regulations,

- Application methods,
- Monitoring, and
- Compensatory mitigation.

The current herbicide application review process allows for review of the application and associated environmental documents by state agencies, Indian tribes, local agencies, and the public. Comments or concerns received during the review process are carefully considered where appropriate. This process allows for coordination of actions related to issuance of water quality modifications for aquatic herbicide applications. However, other activities related to aquatic plant management, such as mechanical harvesting, installation of bottom barriers, weed rolling, funding lake restoration activities and water milfoil control, and issuing permits for rotovation or introduction of grass carp are not coordinated through this process. Under the current system, isolated actions related to aquatic plant management may be taken by a variety of divisions within one or more agencies, funded through separate mechanisms, and carried out under independent mandates.

In addition, our knowledge of and concern with the impacts aquatic herbicides may have on human and environmental health has resulted in new regulations for controlling their use. Changes also occurred in our understanding of aquatic ecosystems, including the role of wetlands and the need to consider and control impacts such as nutrient and sediment loading within the total watershed of any particular waterbody. To address these changes in aquatic plant management, Ecology updated and supplemented the EIS with the *Final Supplemental Environmental Impact Statement for the Aquatic Plant Management Program* (SEIS), dated January 1992. Several control alternatives were examined along with their impacts and potential mitigation of significant adverse impacts. These alternatives included the use of an integrated management approach, use of chemical controls only, physical controls only, or biological controls only, continuation of current practices, or taking no action relative to controlling nuisance aquatic plants.

The 1992 SEIS recommended an integrated approach to aquatic plant management and allows the use of copper, endothall, fluridone and glyphosate to control various types of aquatic plants. Having a variety of control methods available provides the flexibility necessary to control nuisance populations of native as well as invasive non-native species in situations where it is desirable to maintain other, often-conflicting beneficial water uses. The integrated pest management approach identified in the 1992 SEIS as the preferred alternative for controlling nuisance aquatic plant populations allows for the use of the most efficient and effective control method, or combination of control methods, while minimizing impacts to human or environmental health. Having the most up-to-date aquatic herbicides is equally important to encourage the most efficient and effective control method, or combination of control methods, for use for aquatic plant control.

Section V. Use of Mechanical and Manual Methods Only as an Alternative

A. Introduction

Manual methods include hand pulling, cutting, and raking; mechanical methods include mechanical harvesting and cutting, weed rolling and rotovation. Bottom barriers and suction dredging are also included in this alternative.

Impacts associated with the exclusive use of mechanical and physical methods may be similar, although probably reduced in scope, to the no action alternative. Currently, many agency aquatic plant control programs process permits required for mechanical control, including general and individual Hydraulic Project Approvals (HPA) from Washington State Department of Fish and Wildlife (WDFW), shoreline permits from local agencies, Section 404 permits from the U.S. Army Corps of Engineers for diver dredging and rotovation and water quality modifications from Ecology. Under this alternative, Ecology would continue to administer funds for water quality improvement and aquatic plant control. Manual methods are generally more practical for small areas, such as those around docks, in swimming areas, and in areas containing obstructions. These methods are labor intensive but do not require substantial skill, equipment, or expense, and do not result in long-term adverse environmental impacts.

Environmental impacts associated with manual methods are expected to be minimal, however manual harvesting may result in short-term sediment disturbances with potential adverse impacts to water quality and associated biota, including threatened or endangered species if these species are not identified and avoided. When the use of manual methods is confined to small areas, it is expected that impacts would be short term and limited. However, harvesting and rotovation are generally performed on a larger scale and have the potential for wider scale impacts.

B. Bottom Barriers

Bottom barriers can be an efficient method for controlling small areas of problem aquatic plant populations, providing immediate removal from the water column and long-term control. Effectiveness varies depending on the type of barrier used, and control may range from 1-2 years up to 10 years or longer, as long as bottom barrier maintenance is regularly performed. Bottom barriers provide an attractive alternative to other types of control because they can be deployed and left in place for several growing seasons, eliminating the need for repetitive treatments.

Bottom barriers may interfere with fish spawning and may cause a significant decrease in the benthic community, but impacts appear to be limited to the treatment area. Bottom barriers are not selective within the treatment area, but when placed correctly, can be very selective for small, isolated areas. Wetland or "unique" species within the target area could be impacted unless they are identified and avoided.

1. Description

Covering sediment to prevent growth of nuisance aquatic plants is a management option employed since the late 1960s (Born et al., 1973, Nichols, 1974). A bottom barrier covers sediment like a blanket, compressing aquatic plants while reducing or blocking light. Once anchored to the sediment the barrier compresses plant material into contact with microbially active sediments. Bottom barriers should be installed before aquatic plants have started growth in spring or, if installed later in the year, plants should be cut prior to the bottom barrier being placed. Materials such as burlap, plastic, perforated black Mylar, and woven synthetics can all be used as bottom screens. There are also commercial bottom screens that are specifically designed for aquatic plant control. These include:

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

An ideal bottom screen should be durable, heavier than water, reduce or block light, prevent plants from growing into and under the fabric, easy to install and maintain, and readily allow gases produced by rotting weeds to escape without "ballooning" the fabric upwards. Even the most porous materials, such as window screen, will billow due to gas buildup. Therefore, it is very important to anchor the bottom barrier securely to the bottom. Unsecured screens can create navigation hazards and are dangerous to swimmers. Anchors must be effective in keeping the material down and must be regularly checked. Natural materials such as rocks or sandbags are preferred as anchors.

Bottom barriers can provide immediate removal of nuisance plants and maintain a long-term plant-free water column. However, efficacy, durability, longevity, and cost of materials vary. Bottom barrier materials include polyethylene, polypropylene, synthetic rubber, burlap, fiberglass screens, woven polyester, and nylon film. The duration of control provided by a bottom barrier depends on several variables: the amount of fragment accumulation in the site originating from untreated areas, the rate of sedimentation (accumulated sediment may provide substrate for plant fragments to root), the degree to which plants can penetrate the barrier from the underside, and durability of the bottom barrier fabric. For example, burlap rots within two to three years, and plants can grow through window screening material. Regular maintenance can extend the life of most bottom barriers.

Bottom barriers are also one of the most expensive methods for aquatic vegetation control if used in a large-scale application. They are cost effective when used in small areas. Because the material and installation costs can be expensive, bottom barriers are generally applied to small areas such as around docks and in swimming areas. Texel (needle punched polyester fabric) has been recommended for situations where routine maintenance can be performed and long-term control is desired. Burlap is suggested for low-cost, short-term (1 to 2 years) control. Burlap is recommended for early infestation projects where pioneering colonies of invasive exotic plants such as Eurasian water milfoil are covered with fabric that is weighted with rocks or sandbags. In this instance, burlap is used to kill pioneering colonies. Burlap decomposes naturally allowing native species to colonize areas once occupied by invasive plants. Snohomish County personnel reported native species colonizing burlap bottom barriers that were placed over Eurasian water milfoil plants in Lake Goodwin (Williams, 2000). He also noted that in colder waters, burlap remains intact longer than two years.

2. Impacts due to Bottom Barriers

Earth

Sediments Anchoring of bottom barriers may disturb benthic organisms. It may also be difficult in deep soft sediments; thus their use in soft sediments may not be appropriate (Gibbons 1986). Additionally, removal of plants from the water column may affect the rate of sedimentation in the treatment area. Decomposing plants may increase sediment and barriers should be removed before they breakdown, unless they are specifically designed to do so.

A specific concern is the limitation of barrier performance resulting from sediment gas evolution following placement. Available barrier fabrics are reported to differ extensively in both their immediate and long-term permeability to gases (Pullman, 1990). A study of benthic barriers (Dow Bottom Line® - a fabric that is no longer available) in the Eau Gallie Reservoir in Wisconsin showed that barrier placement at the vegetated site was followed almost immediately by release of large quantities of gases, causing the barriers to billow up noticeably (Gunnison and Barko, 1989, 1990). In contrast, no gas collection was observed at unvegetated sites within 3 days of barrier placement and only minor volumes were collected after 8 weeks.

Gunnison and Barko, (1992) conducted laboratory studies to determine the influences of temperature, sediment type, and sediment organic matter on rates of gas evolution beneath a bottom barrier. Gas evolution was measured at 15 and 30° C from sand and clay sediments with and without additions of organic matter (plant matter). The authors concluded that problems with bottom barrier performance related to gas evolution are likely to be greatest in areas of high plant biomass. They recommended that barrier deployment be restricted to periods of the year when the standing crop of macrophytes is low. The second most important factor to consider is water temperature. Barriers should be placed during the cooler months of the year when microbial decomposition rates are low, decreasing the rate of gas release.

Bottom barriers are subject to lifting by gas bubbles from the sediments. Therefore many bottom barriers are porous or perforated to allow for gas release. However, even the most porous of materials may allow gas to accumulate. Periodic inspection of bottom barriers is required to ensure that they do not become a swimming or navigation hazard. Sometimes slits are cut into the fabric to allow gas to escape. Unfortunately, these slits can provide opportunities for aquatic plants to penetrate the barrier.

Also see ESA, Wetland and Sediment Mitigation for All Methods pages 11-14.

Toxicity With the possible exception of sulfides, release of toxic materials is not expected from the use of commercial bottom barriers specifically designed for aquatic plant control or from common materials such as burlap, plastics, perforated black mylar, or woven synthetics. Routine and regular maintenance should be performed to prevent the inadvertent deterioration or loss of the barrier.

Water

Surface Water Adverse impacts to surface water quality may occur if bottom barriers are used on very large areas of aquatic vegetation. Large amounts of rapidly decaying vegetation in non-flowing water can result in oxygen depletion that can lead to fish kills. Use of bottom barriers is not expected to result in a reduction of water quality including low dissolved oxygen in the water column because very large areas would need to be covered. Coverage of such areas is expected to be prohibitively expensive and it is unlikely that WDFW would issue a permit for such an extensive coverage. Ussery et al., (1997) observed a decline in dissolved oxygen to near zero beneath a bottom barrier placed in Eau Galle Reservoir, Wisconsin. This barrier also caused an increase in ammonia. Both impacts should be limited to areas covered by bottom barriers.

Another potential negative impact following bottom barrier use may be the release of organic and inorganic phosphorus during plant decomposition. Increased nutrients may result in rapid phytoplankton growth. This potential impact should not be significant if only small areas are covered.

Public Water Supplies Bottom barrier use should not disrupt public water supplies. Bottom barrier treatment creates an immediate open water column that can be sustained with annual barrier cleaning. (See Surface Water.)

Plants

Plant Habitat Bottom barriers are very effective for immediate removal of plants from the water column and can cause a 90-100 percent decrease in plant biomass. While bottom barriers cause a non-selective loss of aquatic vegetation, they are very selective for small, isolated treatment areas. Their use can have a 2-3 year or longer carryover, but plant colonization of the bottom barrier surface or from below is possible with most materials.

Helsel et al, 1996 compared 2,4-D and a bottom barrier fabric for Eurasian water milfoil control in a Wisconsin Lake. Their objectives were to compare early-season applications of 2,4-D and bottom barriers for selective control of milfoil, re-growth of native macrophytes, and establishment of native plant beds from cuttings. They covered 675 square meters of Dunn Cove (nearly the entire area) with a polyvinyl chloride Palco® liner of 0.50-mm thickness. The bottom barrier was removed after 45 days when the underlying vegetation showed chlorosis and disintegrated easily (some coontail plants apparently survived this treatment). The site was then planted with cuttings of native submersed species. By the next summer the barrier area was dominated by Eurasian water milfoil. The authors concluded that bottom barriers left in place for 45 days were non-selective in controlling covered plants. Replanting the area with native species proved unsuccessful, probably due to ineffective planting techniques and the drift of milfoil fragments from untreated areas. In 2,4-D treated areas, milfoil was selectively removed and native species recovered to 80 to 120 percent of their standing crop within 10 to 12 weeks after treatment.

As a matter of policy Ecology does not support removal of non-noxious emergent (wetland) species except in controlled situations where the intent is to improve low quality (Category IV) wetlands, or situations where the wetlands have been created for other specific uses such as stormwater retention.

Animals

Macro invertebrates A study performed on a lake in Wisconsin revealed a 2/3 reduction of the benthic community after using Aquascreen® for three months (Engel 1990). Ussery et al., 1997 found that macro invertebrate density under the bottom screens declined by 69 percent within 4 weeks of barrier placement at Eau Galle Reservoir, Wisconsin. Within a few weeks of placement at ponds near Dallas, Texas, invertebrate densities declined by more than 90 percent. Barriers also reduced macro invertebrate taxa richness at both locations. However, biotic conditions in affected areas recovered rapidly after barrier removal. Ussery et al., 1997, noted that only macro invertebrates directly under the barrier were negatively impacted.

Fish Sport fish forage more effectively in open areas than in plants. Bottom barriers develop their own relatively dense epibenthic fauna, which could in turn provide food. Bottom barriers would have no chronic impacts on vertebrates. However, bottom barriers can interfere with fish spawning if spawning habitat or sites are covered.

Threatened and Endangered Species Treatment with bottom barriers has the potential to affect submersed and emerged plant species federally listed as rare, threatened, or endangered. Bottom barriers are usually used only for small areas but their use does result in a non-selective loss of aquatic vegetation within the treatment area. Before the use of bottom barriers, the treatment site should be inspected for rare, threatened, or endangered species listed by US Fish and Wildlife. Check with WDFW, Environmental Services Division for fish and wildlife listings and for plant listings with the Washington State National Heritage Data System (http://www.wa.gov/dnr/htdocs/fr/nhp/wanhp.html).

Water, Land and Shoreline Use

Aesthetics Use of bottom barriers results in decreased vegetation in small areas. This may be viewed as either a positive or adverse impact on aesthetics, depending on the attitude of the observer.

Recreation Bottom barrier use on beaches and around docks to reduce heavy vegetation is expected to improve swimming and boating activities. Steel stakes should not be used in shallow water to anchor bottom barriers because they could injure swimmers. Natural anchoring materials such as burlap sandbags or rocks are preferred. Properly maintained bottom barriers in public swimming beaches increase the safety of swimmers by allowing lifeguards to see and rescue swimmers in trouble.

Navigation Use of bottom barriers is suitable for localized controls, such as around docks. To the extent that bottom barriers create small but immediate open areas of water, boat navigation would be improved after their use. Disintegration of bottom barriers into big pieces within the water column or movement of frame mounted barriers are potential dangers to navigation.

3. Mitigation, Bottom Barriers

Permits Bottom screening requires hydraulic approval that can be obtained free of charge from WDFW. If bottom barriers cost less than $2,500, they may be exempt from the Shoreline Management Act (SMA). Barriers costing more than $2,500 may need a Shoreline permit for installation. In any case, interested parties should check with their local government and the pertinent Shoreline Master Plan before installation of bottom barriers.

Sediment, Water, Plants and Animals Impacts from bottom barriers on sediment, water quality, plants including unique or endangered species, and animals should be minimal if used to cover a small percentage of the total bottom area of any waterbody. When there is a large standing crop of vegetation, bottom barriers should be placed in the spring before plants resume growth or in the fall when the plants have senesced. Cutting the plants prior to placement of the barrier will facilitate barrier installation, but gases will still be produced and could cause the barrier to billow.

Important fish spawning areas could be impacted if covered by bottom barriers. To avoid such impacts, the area proposed for treatment should be evaluated to determine its importance to fisheries, and critical spawning areas should be avoided. Application of bottom barriers in lakes where sockeye salmon regularly spawn requires an individual Hydraulic Project Approval (HPA) from WDFW. Application of bottom barriers in other waters may be covered by the *Aquatic Plants and Fish Pamphlet* produced by WDFW. In any event WDFW limits the area that can be covered by bottom barriers. Larger applications of bottom barriers require individual HPAs.

Impacts to federal or state listed sensitive, threatened, or endangered plant species (or species proposed for listing in any of these categories) could be reduced or prevented by excluding them from the treatment area. However, in order to avoid "unique" species, the location of any populations in the treatment area must be identified.

The proponent should determine if such species are in the proposed treatment area by requesting this information from Washington Natural Heritage Information System. This system provides the location of known sensitive, threatened, and endangered species populations. This database contains only known locations so cannot be considered a comprehensive list of all locations of "unique" species in Washington. If the data system indicated that a "unique" species may exist in the project area, a survey should be conducted for field verification and the project redesigned to avoid any unique species observed (Washington State Natural Heritage Information System, 2000).

Also see ESA, Wetland and Sediment Mitigation for All Methods pages 11-14.

C. Suction Dredge (also called diver dredge)

Use of a suction dredge is practical for clearing plants from small areas and from areas containing obstructions, resulting in up to 90% removal. Removal can be very selective for area and for species, but increased sedimentation may obscure vision resulting in less effective harvesting.

Potential environmental impacts associated with use of a suction dredge include turbidity and re-suspension of contaminants and nutrients bound in sediment. If not identified and avoided, wetland or "unique" species may be removed. Due to the high cost of dredging and the difficulty in obtaining permits, its use and attendant impacts are expected to be confined to small areas.

1. Description

Diver dredging is a method whereby SCUBA divers use hoses attached to small dredges (often dredges used by miners for mining gold from streams) to vacuum plant material out of the sediment. The purpose of diver dredging is to remove all parts of the plant including the roots. A good operator can accurately remove target plants, like Eurasian water milfoil, while leaving native species untouched. The operator uses a suction hose to pump plant material and sediments to the surface where they are deposited into a screened basket. The water and sediment are returned to the water column and the plant material is retained. The turbid water is generally discharged to an area curtained off from the rest of the lake by a silt curtain. Plants are disposed of on shore. Removal rates vary from approximately 0.25 acres per day to one acre per day. The suction dredge is used for small areas that require complete removal, are too large for hand removal, and are not appropriate for chemical methods. Furthermore, it can be used where bottom obstructions occur. Use of the suction dredge is slow, labor intensive, and expensive.

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

Toxicity Release of toxic materials is not expected with use of the suction dredge. Areas offshore of storm drains should not be dredged to avoid the possibility of dredging and releasing contaminants concentrated in sediments unless these areas have been first tested using a bioassay.

2. Impacts due to Suction Dredging

Earth

Sediment Suction dredging is used to remove roots and shoots at any water depth. Roots are readily removed from flocculent sediment. Firmer sediments may require the use of a hand tool to loosen the sediment around the roots before suctioning the plant. In hard sediments, suction dredging breaks the plant off at the roots and is not effective. Dredge use disturbs the sediments but only in very small areas of the waterbody. Discharge of the sediments back to the water column and sediments stirred up by the suction head lead to increased turbidity in the water column. The amount of turbidity present in the waterbody may be somewhat dependent on the particle size of the sediment. Fine flocculent sediments will lead to more turbidity being present in the water column following dredging.

Areas offshore of stormwater drains, combined sewer outclass, land fills, and other areas that may contain contaminated sediment should not be disturbed by dredging to avoid the possibility of re-suspension of contaminants such as heavy metals into the water column. Dredging in such areas may release toxic materials. However, it is possible to test for contaminants using bioassay (Cubbage, et.al. 1997).

Air

Use of a suction dredge is expected to have little effect on air quality. Adverse effects related to its use would be associated with dredge equipment and boat or barge movement.

Water

Surface Water Suction dredging will create short-term turbidity in the water column. Dredging can also potentially release nutrients from the sediments, although impacts are expected to be short-term. Since plant materials are removed from the water immediately, decreased oxygen levels from decomposing plants are not expected to occur after treatment (See Sediments, Release of Toxic Materials).

Ground Water Suction dredge use is not expected to affect ground water.

Public Water Supplies Suction dredges may create short-term turbidity in small areas during treatment. However, public water supplies should not be disrupted by dredge use.

Plants and Animals

Plant Habitat Suction dredge use is very site specific and can be species specific. Suction dredging results in 90 percent immediate removal of plant biomass. In turbid water, a non-selective loss of vegetation may occur. Re-growth of plants in dredged areas is possible within one to two years after treatment. Suction dredging will not provide long-term control for plants that propagate by seeds, winter buds, or tubers. It is most effective for plants like Eurasian water milfoil or Brazilian elodea which do not rely on these propagules for reproduction.

Ecology does not support removal of non-noxious emergent (wetland) species except in controlled situations where the intent is to improve low quality (Category IV) wetlands, or situations where the wetlands have been created for other specific uses such as stormwater retention.

Animals Chronic impacts on animals are not expected with suction dredge use. A slight short-term negative impact to aquatic animals may occur as a result of increased turbidity. Some substrate removal may impact benthic organisms; benthic organisms often serve as food for vertebrates. Dredging may also disturb fish spawning areas. WDFW may or may not approve suction dredging in some lakes due to potential impacts on sockeye spawning areas. The local Area Habitat Biologist must be contacted for activities in Baker Lake and Lake Osoyoos, Odette, Pleasant, Canaled, Sammamish, Washington and Wenatchee.

Threatened and Endangered Species. Treatment with a suction dredge has the potential to affect submersed and emerged plant species federally listed as rare, threatened, or endangered. Suction dredges are usually used only in small areas and can be very selective; thus impacts to threatened and endangered species are not expected. Check for threatened, or endangered species listed by US Fish and Wildlife. Check with WDFW, Environmental Services Division for fish and wildlife listings and with the Washington State National Heritage Data System http://www.wa.gov/dnr/htdocs/fr/nhp/wanhp.html for plant listings.

Water, Land and Shoreline Use

Aesthetics Use of the suction dredge results in decreased vegetation in small areas. This may be viewed as either a positive or adverse impact on aesthetics, depending on the attitude of the observer.

Recreation Suction dredge use is expected to improve swimming and boating activities in areas of heavy vegetation. Fishing is not usually affected by suction dredge treatment, except that opening up areas of heavy vegetation allows anglers immediate access to fishing areas. The suction dredge is used primarily in small areas, such as for the early infestation removal of noxious aquatic weeds such as Eurasian water milfoil and/or near obstructions such as docks. Swimming and boating should improve in areas of heavy vegetation after plant removal. Recreational facilities could be closed for short periods during dredge operation.

Navigation Suction dredge use could disrupt navigation routes during treatment. However, suction dredging is expected to improve navigation in treated areas.

3. Mitigation, Suction (or diver) Dredge

Permits Suction dredging requires hydraulic approval that can be obtained free of charge from WDFW. Generally a Temporary Modification of Water Quality Standards permit is needed from Ecology. Local agencies should be consulted to determine if any local regulations apply, but often a shoreline substantial development permit is needed. In addition, the U.S. Army Corps of Engineers should be consulted to determine if a Section 404 permit is needed.

Sediment, Water, Animals, and Plants. Dredging re-suspends sediment and sediment is often discharged back to the water column after the plants are removed. Suction dredging should not be conducted in areas known or suspected to contain contaminated sediments. If contaminated sediments are suspected, sediment samples *must* be tested for toxicity using bioassays or other techniques before permits are issued to diver dredging projects.

Suspended sediments cause turbidity, but impacts are expected to be limited because the treatment area is generally small. If the water/sediment slurry is discharged back into the waterbody, the discharge area should be cordoned off using a silt curtain. This will minimize turbidity impacts. Diver dredging can be tailored to area and plant species unless turbidity decreases visibility. Decreased visibility makes it difficult to target specific plants, so dredging should be suspended if water becomes turbid in areas where certain plants are to be preserved. Check with the Natural Heritage Program (Washington 2000) to ensure that no threatened or endangered or rare plants are within the proposed treatment areas.

As with use of bottom barriers, dredging shall not be conducted in critical spawning areas unless WDFW has given permission to do so. Suction dredging in lakes where sockeye salmon regularly spawn requires an individual HPA from WDFW.

Also see ESA, Wetland and Sediment Mitigation for All Methods pages 11-14.

D. Hand Removal, Cutting, and Raking

1. Description

Manual methods for aquatic weed removal include hand removal, hand cutting, and raking. These methods are labor intensive and are used primarily in swimming areas and around docks. Diver hand pulling is used increasingly to remove pioneering colonies of noxious weeds like Eurasian water milfoil from early infestation sites or to remove plants remaining after herbicide treatments.

Toxicity Release of toxic materials is not expected with the use of manual methods of plant removal.

Hand Removal Hand removal of aquatic weeds is similar to weeding a garden. The ease and success of pulling weeds depends on the type of plant removed and type of sediment in which the plant is rooted. In water less than three feet deep no specialized equipment is required, although a spade, trowel, or long knife may be needed if the sediment is packed or heavy. In deeper water, hand pulling is best accomplished by divers with SCUBA equipment and mesh bags for the collection of plant fragments. After pulling plants from sediment, the harvester should collect all plants and fragments from the water to avoid spreading nuisance plants.

In early infestation projects, extreme care should be taken to avoid fragmentation of the plant. In some instances, a diver goody bag should be placed around the plant before pulling to catch any fragments that result. Any escaped fragments should be collected with a rake and disposed of on land. After pulling plants from sediment, the harvester should collect all plants and fragments from the water to avoid spreading nuisance plants.

Cutting Cutting differs from hand pulling in that plants are cut and the roots are not removed. Cutting is performed by standing on a dock or on shore and throwing a cutting tool into the water. Cutting generates floating plants and fragments that must be removed from water to prevent re-rooting or concentrating on nearby beaches. Weed rakes or specialized nets can be used to facilitate plant cleanup. A commercial non-mechanical aquatic weed cutter consists of two single-sided stainless steel blades forming a "V" shape. The blades are connected to a handle and to a long rope that is used to pull the cutter after it is thrown into a nuisance population of aquatic plants. As the cutter is pulled through the water, it cuts a 48-inch swath through the weeds. Cut plants rise to the surface where they can be collected and removed. Hand-held battery-powered cutters are similar to weed eaters. A long, underwater cutting blade works like a hedge trimmer to cut aquatic plants in a four-foot swath up to twelve feet below the water surface.

Raking A sturdy rake can be used to remove aquatic plants from swimming areas and around docks. Ropes can be attached to the rake to allow removal of offshore plants, and floats can be used to allow easier plant and fragment collection.

2. Impacts Due to Hand Removal, Hand Cutting, and Raking

Earth

Sediments Hand removal or raking of aquatic plants may result in some substrate removal and a short-term increase in turbidity. Increased turbidity may make it difficult to see remaining plants and may disturb benthic organisms. The degree of turbidity will depend on the type and texture of the sediment, the density of the plants being removed, and the depth of the plant roots. Removal of dense plant beds may change the flow rate and sedimentation rate in flowing waters (this holds true for all the other methods too).

Also see ESA, Wetland and Sediment Mitigation for All Methods pages 11-14.

Water

Surface Water Hand removal and raking of aquatic vegetation may result in increased turbidity in limited areas during treatment. If pulled or cut plants are removed from the water, increased nutrients and/or decreased oxygen levels are not expected to occur in the treated lake or pond; however there may be some increase in nutrients due to sediment re-suspension. These effects are expected to be short-lived.

Public Water Supplies Manual methods (especially hand-pulling of plants) may result in a short-term turbidity increase in the treatment area.

Plants and Animals

Plant Habitat Hand pulling can be species specific in removal of aquatic vegetation with a minimum disruption of native plants. It is more difficult to target specific species during raking or cutting activities. It is hard to collect all plant fragments using manual methods, some species are very difficult to uproot with manual methods, and treatment may be required several times each summer. Because it is so labor intensive, manual plant removal is not practical for large areas or for thick weed beds.

Ecology does not support removal of non-noxious emergent (wetland) species except in certain situations where the land managers plan to improve low quality wetlands (Category IV) and in wetlands created for other specific uses such as stormwater retention.

Animals Hand removal of aquatic plants disturbs benthic organisms. Since manual methods are slow and labor intensive, removal of an entire lake plant community is not expected. Therefore habitat for other aquatic organisms (such as fish) is not expected to be greatly impacted by the use of manual methods.

Threatened and Endangered Species Manual methods of aquatic plant removal have the potential to affect submersed and emergent plant species federally listed as rare, threatened, or endangered. However manual methods can be species specific in removal of plants and are generally used for small areas so if identified, these species can be avoided.

Priority fish species, such as the Olympic mud minnow and federally listed species such as sockeye salmon, including their spawning areas, may be impacted by hand removal, hand cutting and raking. Before manual methods are used for plant removal, each site should be reviewed for rare, threatened or endangered species listed by US Fish and Wildlife. “Proposed sensitive" plants are also listed by Washington State National Heritage Data System and the WDFW has lists of fish and wildlife of local concern. Check with the local Area Habitat Biologist.

Water, Land and Shoreline Use

Aesthetics Manually removing vegetation from small areas may be viewed as either a positive or adverse impact on aesthetics, depending on the attitude of the observer.

Recreation Manual removal of plants on beaches and around docks is expected to improve swimming and boating activities. Fisheries are not expected to be affected by manual treatment of relatively small areas of aquatic vegetation.

Navigation Use of manual methods is suitable for localized control, such as in swimming areas and around docks. Small open areas of water which result from manual method use will improve boat navigation.

3. Mitigation, Manual Methods

Permits Hand-pulling, raking, and cutting (including battery-powered equipment) requires an HPA from WDFW. Manual methods in lakes where sockeye salmon regularly spawn requires an individual HPA from WDFW. Manual techniques in other waters may be covered by the *Aquatic Plants and Fish Pamphlet* produced by WDFW. In any event, WDFW limits the area of aquatic plants that can be removed by manual methods.

Sediment, Water, Animals, and Plants Small-scale manual methods would minimally impact these elements of the environment. Nevertheless, care should be taken to avoid unique plant species and critical fish spawning areas. Also see ESA, Wetland and Sediment Mitigation for All Methods pages 11-14.

E. Rotovation

Rotovation is performed using agricultural tilling machines that have been modified for aquatic use, or machines that have been specially designed for rotovation. Rotovators use underwater rototiller-like blades to uproot aquatic plants. Rotating blades churn seven to nine inches deep into the lake or river bottom to dislodge plant roots. Plant roots are generally buoyant and float to the surface of the water. Generally, rotovators are able to extend 20 feet under water to till substrate, and may be able to till shallow shoreline areas if access is not limited by the draft of the machine. Rotovators do not collect roots and plant fragments as plants are uprooted. However, plants and roots may be removed from the water using a weed rake attachment to the rototiller head, by harvester, or manual collection. In Washington and British Columbia, rotovation is primarily used to remove Eurasian water milfoil from lakes and rivers. Rotovation was also used to successfully remove water lily (*Nymphaea odorata*) rhizomes from a lake near Seattle. Rotovation appears to stimulate the growth of native aquatic plants, so it would probably not be an effective tool to manage excessive growth of nuisance native species.

The optimum time for rotovation extends from late fall to spring. During this period, plant biomass is reduced as is the number, buoyancy, and viability of plant fragments; water levels; and conflicts with beneficial uses of the water body (Gibbons, Gibbons, Pine; 1987). Due to increased plant biomass during summer months, plants must be cut before rotovation. Otherwise the long plants tend to wrap around the rototilling head.

The area that can be rotovated per day can range from 2 acres to less than 1-acre depending on plant density, time of year, bottom obstructions, plant species, and weather conditions. Generally, rotovators are not able to operate efficiently in winds over 20 miles per hour. Imprecise tracking of treated areas may result in incomplete removal of target plants, ultimately reducing long term-control. Tracking efficiency can be improved with use of buoys.

Rotovation can effectively control milfoil for up to two seasons. Deep-water rotovation has resulted in an 80% to 97% reduction of milfoil, with control lasting up to two years. The rotovated area is eventually re-colonized by milfoil fragments that float in from untreated areas or from plants remaining after rotovation.

WDFW considers rotovators to impact fish and invertebrates in at least three ways: 1) There is a high potential for rotovators to cause direct mortality; 2) Disturbance of the lake bottom increases turbidity; and 3) There is a potential release of toxic substances and nutrients from sediments. Other impacts include removal of vegetative habitat and an increase in predation of small fish by larger fish due to increased visibility. Rotovation temporarily disrupts the benthic community, which in turn could impact benthic feeders. Rotovation is not selective within the treatment area and could result in removal of desirable species such as wetland vegetation or "unique" species. However, removal of monotypic vegetation such as milfoil may ultimately increase diversity of desirable species and rotovation appears to stimulate the growth of native aquatic plants.

Use of rotovators can result in plant fragments. If not collected, decaying plant fragments could reduce dissolved oxygen levels and increase nutrients. Plant fragments could also clog water intakes and trash racks of dams, and may result in increased dispersal and colonization of some species (including Eurasian water milfoil). Rotovation should be used only in waterbodies where Eurasian water milfoil fully occupies its ecological niche. Otherwise rotovation could tend to spread Eurasian water milfoil throughout the waterbody rapidly. As discussed in the "Impacts" section, mitigation measures could be designed to reduce or avoid some of the impacts discussed.

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

1. Impacts Due to Rotovation

Earth

Sediments The rotovator's tiller head can penetrate sediment to a depth ranging from 7 to 9 inches. Rotovation re-suspends sediments, resulting in turbidity and increasing the potential for re-suspending toxic substances. Depending on sediment consistency (muck, sand, etc.) and density of the root mass, root removal may increase the amount of sediment re-suspended and the depth to which sediment is disturbed (Moore, A. Personal communication.). Sediments in the treatment area could be contaminated with metals, pesticides, or other toxic substances as a result of historical or existing uses. Sediments may also contain high levels of nutrients, which if re-suspended could fuel phytoplankton blooms and dissolved oxygen sags.

Sediment disruption may cause movement of contaminants, either to the sediment surface or into the water column. Only narrative standards have been set for fresh water sediments so it is difficult to assess benthic impacts, which would vary depending on the type and concentration of contaminant. The Lake Osoyoos Rotovation Demonstration Project (Gibbons, Gibbons, Pine, 1987) characterized surficial sediment quality before and 2.5 months after rotovation. Lake Osoyoos was chosen as the study site for rotovation because land use practices made it likely to have sediments contaminated with heavy metals and pesticides. In most cases, where metals were detected before treatments, levels were elevated after treatment.

Gibbons et. al. 1987, concluded that there was no apparent effect from rotovation on the limited number of species comprising the benthic community in Lake Osoyoos. However, data indicate that species shifts did occur and that there was a post-rotovation reduction in diversity of benthic species. This reduction was most noticeable two months after rototilling but still in evidence 5 months later. Also see ESA, Wetland and Sediment Mitigation for All Methods pages 11-14.

Water

Surface Water (see also, sediment section) Lake Osoyoos Rotovation Demonstration Project researchers concluded that rotovation may have minimal impacts on water quality (Gibbons, Gibbons, and Pine; 1987). However, study results may not have been conclusive because the rotovator periodically malfunctioned, resulting in less intensive tilling and thus less disruption of sediment. Researchers found that rotovation did not alter dissolved oxygen levels, pH, or water temperature. Rotovation caused temporary turbidity, and phosphorous levels were slightly elevated for the first 24 hours after treatment.

Water quality samples taken before, during, and after rotovation were sampled for pesticides and 13 metals. Copper, nickel, and zinc were the only metals above detection levels in any sampling period. Concentrations of copper and nickel showed a minimal increase after treatment, however the level of zinc in the drift zone exceeded Chronic EPA Freshwater Biota Criteria. The high level of zinc in the drift zone may be linked to rotovation, indicating a potential for adverse impacts to water quality from rotovation. Additional research would be required to accurately characterize the potential impacts of sediment disturbance from rotovation on water quality. Since impacts could vary dramatically among rotovation sites, impacts should be assessed for each proposed treatment site. Lake Osoyoos was chosen as the study site because it represents a worst case scenario for heavy metals and pesticides due to land use practices around the lake.

Incidental loss of hydraulic fluid or other petroleum products may also impact water quality. If fluid lines are not maintained and proper care not taken when changing equipment such as cutter heads, the number of incidents of release of petroleum products to surface water could be high although the amount of fluid lost each time may be moderate (~5 gallons). If equipment were not maintained the amount of fluid lost could be much greater (~50 gallons), particularly if hoses were not equipped with shut-off valves (Cornett and Hamel, Personal communication. 1991). Also, in-water disposal of plant fragments could result in reduced dissolved oxygen levels as plant matter decomposes, potentially resulting in fish kills.

Cut plants leak nutrients back to the water column, generally within one hour of being cut. Unless a plant harvester immediately harvests cut plants, some plant nutrients would enter the water.

Water Supplies If cut plants were not removed from the water after treatment, fragments could clog water intakes. In addition, rotovation itself may damage individual water intake pipes. Turbidity or re-suspended contaminants could impact water supplies. The potential for and level of impacts would depend on the proximity of an intake to disturbed sediments and the amount and toxicity of re-suspended contaminants. See "sediment" section.

Plants and Animals

Plants Rotovation has resulted in a 80% to 97% reduction of Eurasian water milfoil stem density with control lasting up to two years (Gibbons, Gibbons, Pine, 1987; Hamel, Personal communication.). Rotovation has been shown to alter species composition and increase species diversity of desirable plant species. Removing milfoil and rototilling appears to stimulate seed germination and growth of native species (Hamel, K. Personal communication.). Rotovation is not selective within the target area, therefore any desirable species in the target area, including wetland species, would be removed on a temporary basis.

Animals Removal of desirable plant species may eliminate valuable habitat for a variety of animal species. However rotovation of milfoil increases plant species diversity, which enhances habitat.

Some disturbance of behavioral patterns could be expected, particularly if spawning or rearing areas were disturbed. Impacts would depend on species using the water body, habitat value of plants removed, and level of disruption. WDFW considers rotovators to impact fish and invertebrates in a least three ways: 1) There is a high potential for rotovators to cause direct mortality; 2) Disturbance of the lake bottom increases turbidity; and 3) There is a potential release of toxic substances and nutrients from sediments. Other impacts include removal of vegetative habitat and an increase in predation of small fish by larger fish due to increased visibility. An HPA is required for all rotovation projects and any priority, threatened or endangered species need to be identified.

In the long term, rotovation to remove Eurasian water milfoil may benefit fish by removing a monotypic species and replacing it with a diverse native community. In British Columbia, rotovation has been used to remove Eurasian water milfoil from salmon spawning beds that had been invaded, thus returning them to use by salmon.

Threatened and Endangered Species Rotovation is not selective. Any sensitive, threatened, or endangered plant species within the treatment area would be temporarily eliminated. However, both the rotovation process and removal of milfoil from an area appear to have a stimulatory effect on native aquatic plants. Native plants may prosper after rotovation.

Energy, Transportation, and Natural Resources

Rotovation above dams could interfere with power generation if plant fragments were allowed to clog trash racks of dams (Hamel, K. personal communication). Eurasian water milfoil does produce fragments on its own and these naturally produced fragments also impact dams.

2. Mitigation, Rotovation

Permits WDFW requires an HPA prior to rotovating and before deadheads or logs can be removed and in many cases will not allow woody debris to be removed from a waterbody. Ecology requires a permit, counties and cities sometimes require a shoreline permit, and the Army Corps of engineers may require a Section 404 permit.

Water/Sediment Quality A review of historical and current use of the proposed treatment area may be required to help determine if contaminants exist in sediments in the treatment area. Should this or other information indicate that sediments might be contaminated, permitters may require a sediment bioassay on suspected sediments prior to issuing a permit for rotovation. Work in or near the waterway should be done so as to minimize streambed erosion, turbidity, or other water quality impacts.
Maintenance and operation procedures performed on rotovation equipment could release petroleum products or other toxic or deleterious materials into surface waters. Thus, such procedures may be required at upland locations to prevent entry of toxic substances into waters of the state.

Due to the high probability of hydraulic fluid or fuel leakage into state waters caused by equipment failure or poor maintenance, permitters may require a detailed inspection plan complete with maintenance logs to be kept and available for inspection. Additionally, operators may be required to complete a daily inspection of all hydraulic equipment, fuel systems, and other systems that may cause petroleum products to be discharged to waters of the state. Permitters may also require that no extra fuel or hydraulic oil be kept on board the rotovator in excess of the amount necessary for emergency repair or re-fueling. To minimize impacts should a spill occur, operators may be required to carry on board the rotovator at all times oil-spill materials such as a containment boom and absorption pads. They may be required to develop a spill contingency plan. The hydraulic system of rotovators should be upgraded to operate only on food grade oil only.

To avoid impacts associated with plant fragments, the applicant may be required to dispose of vegetation on land in such a manner that it cannot enter into the waterway or cause water quality degradation to state waters. Also see ESA, Wetland and Sediment Mitigation for All Methods pages 11-14.

Public Water Supplies. To avoid damage to water intake pipes, individuals should be given adequate notice of the treatment and informed of the potential for damage to intake pipes. Intakes may be pulled from the water prior to treatment.

Plants and Animals. Ecology does not support removal of non-noxious emergent (wetland) species except in controlled situations where the intent is to improve low quality (Category IV) wetlands or situations where wetlands have been created for other specific uses such as stormwater retention. Areas containing desirable species, such as emergent wetland species, should be avoided.

An evaluation of each proposed treatment site should be required to determine if the site is used by fish for spawning, rearing, or other purposes. If the area does provide important habitat, the proposal should be designed to avoid impacts, either by avoiding or limiting the treatment area, or scheduling treatment to avoid interference with critical uses. Turbidity and disturbance caused by rotovation may interfere with juvenile salmon or fish passage. Therefore, WDFW imposes timing restrictions on when rotovation may be allowed to occur within each waterbody. Because timing restrictions have been severe in salmon-bearing waters and because rotovation is extremely expensive, it has not become a popular method of aquatic plant control in Washington.

F. Mechanical Cutting and Harvesting

Mechanical Harvesting. Mechanical cutting and harvesting are practical for large-scale (several acres) vegetation removal because they remove plants from large areas in a relatively short time. Re-growth may occur within one month after cutting or harvesting; therefore several treatments per season may be required. While these methods may be useful for control of aquatic vegetation, they would not result in total eradication of noxious species such as Eurasian water milfoil.

Use of these methods has the potential to result in some significant adverse environmental impacts, but impacts would generally occur within the target area. Mechanical cutting and harvesting may disturb sediments but only if the equipment is operated in areas too shallow for the cutter setting. Mechanical cutting and harvesting are non-selective and could eliminate valuable fish and wildlife habitat within the target area. Generally some plant biomass remains in the water and is available as habitat. Additionally, research indicates that operation of mechanical harvesters can kill up to 25% of small fish in a given treatment area.

Use of cutters, and harvesters to a much lesser degree, can result in accumulation of plant fragments. If not collected immediately, decaying plant fragments can reduce dissolved oxygen levels and increase nutrients. Cut plants leak nutrients back into the water column within one hour of being cut. Plant fragments could also clog water intakes and trash racks of dams, and may result in increased dispersal and colonization of some species. Disposal of fragments is another consideration.

Local jurisdictions (cities, counties) may require shoreline permits for harvesting or cutting activities and an HPA is required from WDFW.

Mitigation measures could be designed to avoid or minimize some of the impacts identified above.

1. Description

Mechanical harvesters are large specialized floating machines that cut, collect, and store plant material. Cut plants are removed from the water by a conveyer belt system and stored on the harvester until removed for disposal. A barge stationed near the harvesting site for temporary storage is an efficient storage method; alternately the harvester carries cut plants to shore. Cut plants may be disposed of in landfills, used as compost, or used to reclaim spent gravel pits or similar sites.

Harvesting is usually performed in late spring, summer, and early fall when aquatic plants have reached or are close to the water's surface. Harvesters may operate every day throughout the growing season, particularly if the treatment area is large. Harvesters can harvest several acres per day depending on plant type, density, and harvester storage capacity. Depending on the equipment used, plants are cut from five to ten feet below the water surface in a swath six to twenty feet wide. Because of the large machine size and cost, harvesting is most efficient in water bodies larger than a few acres. Harvesting can be used as a nutrient removal technique because the cut plants are immediately removed from the water and disposed of off-site. Thurston County performs a fall harvesting to remove senescing plants and their nutrients from the Long Lake. Harvesting can be a nutrient management technique in swallow eutrophic systems.

Mechanical Plant Cutters. Two commercial types of mechanical underwater plant cutters are available. Portable Boat Mounted Cutting Units are portable boat-mounted cutters that can be installed on a fourteen-foot or longer boat and is capable of cutting a seven-foot swath four feet below the waters surface at a rate of about one acre per hour. Specifications may vary depending on the manufacturer of the equipment.

Specialized Barge-like Cutting Machines are mechanical cutters similar to harvesters but differ in that cut plants are not collected as the machinery operates. These machines can cut plants in water as shallow as 10 inches and as deep as 5 feet, with the main sickle cutting a ten-foot wide swath. Specifications may vary depending on the manufacturer of the equipment. Specialized barge-mounted cutters can cut up to 12 acres of plants per day in open water. Cutting is generally performed during the summer when plants have reached or are close to the water surface.

Effectiveness of mechanical harvesting and cutting for controlling aquatic vegetation depends on depth of cut from surface and bottom, time of year, plant density and biomass, distance to off loading sites, cutting speed of the equipment, and the number of cuts per season. Literature specific to Eurasian water milfoil identifies the proximity of the cutter head to milfoil root crowns as a factor-influencing efficacy. Harvesting and cutting can interfere with carbohydrate allocations from roots and shoots, which in turn can weaken the plant making it more susceptible to natural controls (Gibbons, 1986). It can also affect storage of nutrients so that it may not over winter as well and may not grow as vigorously the following year (Hamel, K. 1991).

Cutting and harvesting both result in immediate areas of open water; however, two or three treatments per season may be required to maintain open water. Cutters are smaller than harvesters and are generally more maneuverable allowing for plant removal around docks, boat moorages, and restricted areas.

2. Impacts Due to Mechanical Harvesting and Cutting

Earth

Sediments. Incidental sediment disturbance may occur if blades on barge-mounted mechanical cutters are set too deep. Paddle wheels on some mechanical harvesters may re-suspend sediments (Engel, 1990). If cutters or harvesters disturb contaminated sediments, contaminants could be released into the water column, with the potential impact depending on the toxicity and amount of contaminant released.

Collected plants must be disposed on land, which requires off loading sites to be identified. Adverse impacts to the shoreline may occur as heavy equipment is used to remove cut plants from the harvester. The plants must be disposed in landfills or can be used for compost.

Water

Temporary turbidity could result if sediments were disturbed. If cut plants were not removed from the water, decaying plant material could deplete dissolved oxygen levels and increase nutrients. Also, uncollected plant fragments could clog water intake systems.

Plants and Animals

Plants. Mechanical cutters and harvesters are not selective within the target area; therefore any desirable species within the target area may be cut and collected. Uncollected plant fragments may increase dispersal and colonization of noxious species such as Eurasian water milfoil. Some plant fragments escape even the best of harvesters. These plant fragments may drift into other parts of the waterbody and take root, while others may wash up on shore.

Mechanical harvesting could affect the composition of plant communities (Engel, 1990). After harvesting in a Wisconsin Lake, vegetation was altered from a predominant mix of coontail, Berchtold's pondweed, curly-leaf pondweed, and sago pondweed to a six-year dominance by water star grass. Generally plants that reproduce sexually, regenerate poorly from cut parts, heal and re-grow poorly when cut, and are tall are most vulnerable to harvesting (Nicholson, 1981). These characteristics fit many native species, especially the pondweeds (*Potamogeton* spp.). Plants like Eurasian water milfoil may be favored by harvesting. In Lake Wingra Wisconsin, Stanley et al, 1994, compared areas with a history of mechanical harvesting to other areas with no known management history. Although species diversity and taxa richness in three out of four un-harvested areas were greater than in the harvested area, no differences in diversity of plant biomass could be attributed solely to the harvesting regime.

Harvesting has been used extensively in Lake Minnetonka, Minnesota, to control Eurasian water milfoil. Crowell et al., 1994 measured effects of harvesting in five locations in Lake Minnetonka and reported that the relative growth rates of plants in the harvested area were greater than in adjacent un-harvested plots. However, the increased growth rate did not result in greater canopy density or higher total shoot biomass in the harvested areas. Harvesting also reduced the plant abundance at the water surface for up to 6 weeks following the harvest, when harvested in early July. Other researchers have found that harvesting reduced biomass for only three to four weeks (Cooke et al., 1990). Seasonal timing of harvesting may affect the duration of control

Animals. Reduction of desirable plants from the upper water column through harvesting or cutting may remove habitat used by animals and waterfowl for wintering, breeding, rearing, nesting, and feeding, as well as alter migration routes. The severity of impact would depend on the value of habitat removed and location (i.e. proximity to flyways, migration routes, etc.). Physical intrusion may alter animal behavior, although information related to this impact was not available.

Mikol 1985 estimated that 2226-7420 fish per hectare were removed by conventional harvesting of plant beds dominated by Eurasian water milfoil. Similar removal rates were observed in a two-year Wisconsin study where mechanical harvesting of 50 to 70% of submersed plants in Halverson Lake killed 2100 fish per acre harvested, or about 25% of all fry in the lake (Engel, 1990). Because adult fish are more able to flee or avoid the treatment area, impacts on adult fish were less than those on fry. Other factors found to influence the number of fish killed were the number, size, and location of fish, and harvester handling. In some lake systems, especially those with an overabundance of aquatic plants, removal of juvenile warm water fish such as bluegills may actually improve the fishery.

This Wisconsin study also found that harvesting resulted in a loss of 22% (in June) and 11% (in July) of all plant-dwelling macro invertebrates in the lake. Patches of displaced snails, caddis fly larvae, and chironomids drifted about Halverson Lake and onto shores after harvesting. Both bass and bluegills were seen devouring insects dislodged during harvesting. Harvesting had a minimal effect on phytoplankton.

In a 1996 harvesting study on Lake Keesus, Wisconsin, Booms estimated that annual harvesting operations removed about 39,000 fish from this lake. Bluegills between 4 and 10 cm in length were the most common fish removed comprising 46 percent of the fish taken. Others included largemouth bass (24 percent), unidentified fry (16 percent), and black crappie (8 percent). Generally smaller fish were removed. Mud puppies, adult and immature bullfrogs, and larger fish (12 – 56 cm long) were occasionally harvested during normal harvesting operations. Booms estimated that approximately 700 turtles were also removed during the 1996-harvesting season.

The native weevil (*Euhrychiopsis lecontei* Dietz) has been proposed as a possible biological control for Eurasian water milfoil. Sheldon and O'Bryan, 1996, investigated impacts of a harvesting program on weevil densities in Lake Bomoseen Vermont. The found that there was a significant negative effect of weed harvesting on weevil abundance. There were fewer weevils found in the harvested sites, whereas weevil densities in un-harvested sites remained higher. Milfoil weevils spend most of their time in the 1.5-m apical portion of plants which is the part of the plant removed by the harvester.

Threatened and Endangered Species. Mechanical cutting and harvesting is not selective. Any sensitive, threatened, or endangered plant species within the treatment area would be cut and collected. Cutting a plant does not necessarily eliminate it. Care should be taken to avoid harvesting threatened or endangered plants.

A harvesting operation could remove juvenile salmon from plant beds. Harvesting operations in salmon bearing waters should be carefully evaluated before permits are issued to harvest.

Water, Land and Shoreline Use

Recreation. Swimming, fishing and other forms of recreation should be restricted in areas in which cutters or harvesters were operating to avoid danger to recreationalists. Generally harvesting and cutting operations open up large areas of water and provide better recreational opportunities for swimming, boating and fishing. Using harvesters to cut fishing lanes can increase fish and fishing productivity by providing plant bed edges. Fish, such as bass, can target smaller food fish and anglers have better fishing access in such areas.

3. Mitigation, Mechanical Harvesters and Cutters

Permits. Harvesting in Washington requires an HPA from WDFW. Some Shoreline Master Programs may also require permits for harvesting. Check with your city or county government.

Sediment. To minimize sediment disruption, operators may be required to insure that the depth of mechanical cutter blades and harvester wheels would not extend into the sediment. Operators may be instructed to limit activities to waters more than five feet deep or so.

Water. Operators may be required to remove all cut plants from the water so as to avoid impacts to water quality and public water supplies.

Also see ESA, Wetland and Sediment Mitigation for All Methods pages 11-14.

Plants and Animals. To avoid impacts related to loss of habitat, a survey of each area proposed for treatment may be required to determine habitat value of plant species, and the potential impact of plant removal. Survey results would dictate appropriate mitigation, which could include limiting the size or location of the harvest area, and/or extent of the harvest. Proponents may be required to design the project to avoid migration routes, critical habitats, including wintering, breeding, rearing, nesting, and feeding habitats. The duration of control may be lengthened by harvesting later in the season (July instead of May or June).

To minimize fish losses, operators may be required to remove fish as plants move up the harvester conveyor belt. Fish loss may also be reduced or prevented by altering the harvest schedule to accommodate fish spawning, rearing, or other behavior. For example, if fry use near-shore areas in early summer, harvesting of these areas could be delayed until fry moved out of the treatment area. Thurston County specifically avoids harvesting areas of thin-leaved pondweeds because they found that these areas support large populations of fish. Appropriate mitigation may require assessment of species use and behavior in the proposed treatment area.

Areas should be set aside for conservation where the milfoil eating weevil *Euhrychiopsis lecontei* is present and desired as a biological control for Eurasian water milfoil. These areas could include shoreline areas where there was no human activity or in areas where harvesters could not effectively cut (extensive shallow areas). However, in order to avoid "unique" species, the location of any populations in the treatment area must be identified.

At a minimum, the applicant could be required to provide verification of a search of the Washington Natural Heritage Information System and WDFW, which provide the locations of known sensitive, threatened, and endangered species populations. If a "unique" species may exist in the project area, a survey should be conducted for field verification, and the project redesigned to avoid any unique species observed.

The proponent may be required to establish setbacks from breeding sites, nests, and feeding or perching areas for federal and state sensitive, rare, threatened, endangered, or unique species and species proposed for listing as such.

References

Booms, T.L. 1999. Vertebrates removed by Mechanical Weed Harvesting in Lake Keesus, Wisconsin. Journal of Aquatic Plant Management 37: 34-36.

Born, S.M., T.L. Wirth, E.M. Brick, and J.P. Peterson, 1973. Restoring the recreational potential of small impoundments; the Marion Millpond Experience. Technical Bulletin 71, Department of Natural Resources, Madison, WI.

Cooke, G.D., A. B. Martin and R.E. Carlson. 1990. The effect of harvesting on macrophyte re-growth and water quality in LaRue Reservoir, Ohio. J. Iowa Acad. Sci. 97: 127-132.

Coots, Randal. Personal communication. Washington State Department of Ecology. February 8, 1991.

Cornett, Deborah, Personal communication. Washington State Department of Ecology. February 28, 1991.

Crowell, W., N. Troelstrup Jr., L. Queen, and J. Perry. 1994. Effects of harvesting on plant communities dominated by Eurasian water milfoil in Lake Minnetonka, MN. Journal of Aquatic Plant Management. 32: 56-60.

Cubbage, J., Batts, D., Breidenbach, S. 1997. Creation and Analysis of Freshwater Sediment Quality Values in Washington State. Washington State Department of Ecology, Olympia, WA. Publication No. 97-323a.

Engel, S. 1990. Ecological impacts of harvesting macrophytes in Halverson Lake, Wisconsin. J. Aquat. Plant Manage. 28:41-45.

Gibbons, M.V. 1986. Literature review on the effectiveness of mechanical harvesting and three herbicides and status of other control methods for Eurasian water milfoil. Prepared for Municipality of Metropolitan Seattle.

Gibbons, M. V., H. L. Gibbons, and R. Pine. 1987. 1986 Lake Osoyoos demonstration project. Prepared for the Washington Department of Ecology.

Gunnison, D. and J.W. Barko. 1989. Effects of benthic barriers of substratum conditions: an initial report. Pages 175-180 in Proceeding 23rd Annual Meeting, Aquatic Plant Control Research Program, Miscellaneous Paper A-89-1. US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Gunnison, D. and J.W. Barko. 1990. Environmental factors influencing gas evolution beneath a benthic barrier. Pages 228-233 in Proceeding 24th Annual Meeting, Aquatic Plant Control Research Program, Miscellaneous Paper A-90-3. US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Gunnison, D. and J.W. Barko. 1992. Factors influencing gas evolution beneath a benthic barrier. Journal of Aquatic Plant Management 30: 23-28.

Hamel, K. Personal Communication. Washington State Department of Ecology. January 30, 1991, February 7, 1991, February 28, 1991.

Helsel D.R., D.T. Gerber, and S. Engel, 1996. Comparing spring treatments of 2,4-D with Bottom Fabrics to Control a New Infestation of Eurasian Water milfoil. Journal of Aquatic Plant Management 34: 68-71.

Moore, Allen. Personal communication. Washington State Department of Ecology. February 7, 1991.

Nichols, S.A., 1974. Mechanical and habitat manipulation for aquatic plant management; A review of techniques. Technical Bulletin No. 77. Department of Natural Resources, Madison, WI.

Pullman, G. D. 1990. Benthic Barriers Tested. Lake Line, 10 (4): Pages 4 and 8.

Mikol, G. F. 1985. Effects of harvesting on aquatic vegetation and juvenile fish populations at Saratoga Lake, New York. Journal of Aquatic Plant Management. 23: 59-63.

Nicholson, S. A. 1981. Changes in submersed macrophytes in Chautauqua Lake, 1937-1975. Freshwater Biol. 11: 523-530.

Sheldon, S.P., and L. M. O'Bryan. 1996. The effects of harvesting Eurasian water milfoil in the aquatic weevil Euhrychiopsis lecontei. Journal of Aquatic Plant Management. 34: 76-77.

Stanley, A. and R. C. Lathrop. 1994. Impact of Harvesting on Aquatic Plant Communities in Lake Wingra, Wisconsin. Journal of Aquatic Plant Management. 32: 33-36.

Ussery, T. A., H.L. Eakin, B.S. Payne, A.C. Miller, and J.W. Barko, 1997. Effects of Benthic Barriers on Aquatic Habitat Conditions and Macro invertebrate Communities. Journal of Aquatic Plant Management 35: 69-73.

Washington State National Heritage Data System. 2000: Washington State Department of Natural Resources, National Heritage Program: (http://www.wa.gov/dnr/htdocs/fr/nhp/wanhp.html).

Williams, Gene. 2000. Washington State Lake Protection Association (WALPA) Presentation. SeaTac, WA, April 2000.

Section VI. Biological Methods Only as an Alternative

A. Introduction to Biological Controls

Under this alternative, agencies process permits or funding allowing the introduction of sterile grass carp (*Ctenopharygodon idella*) into waters of the state. Other biological methods reviewed in this SEIS, including plant pathogens, herbivorous insects, competitive plants, and plant growth regulators, are not yet realistic alternatives. Many of these options appear to be promising alternatives for aquatic plant control and may be considered after undergoing further laboratory and field analysis.

The grass carp, also known as the white amur, is a fish native to the Amur River in Asia. Because this fish feeds on aquatic plants, it can be used as a biological tool to control nuisance aquatic plant growth. In some situations, sterile grass carp may be permitted for introduction into Washington waters.

Permits are most readily obtained if the lake or pond is privately owned, has no inlet or outlet, and is fairly small. The objective of using grass carp to control aquatic plant growth is to end up with a lake that has about 20 to 40 percent plant cover, not a lake devoid of plants. In practice, grass carp often fail to control the plants or all the submersed plants are eliminated from the waterbody. The Washington Department of Fish and Wildlife determines the appropriate stocking rate for each waterbody when they issue the grass carp-stocking permit. Stocking rates for Washington lakes generally range from 9 to 25 ten-to-eleven-inch fish per vegetated acre. This number will depend on the amount and type of plants in the lake as well as spring and summer water temperatures. To prevent stocked grass carp from migrating out of the lake and into streams and rivers, all inlets and outlets to the pond or lake must be screened. For this reason, residents on waterbodies that support a salmon or steelhead run are rarely allowed to stock grass carp into these systems.

In Washington, grass carp are only occasionally planted into lakes. These are most often small private lakes or artificial golf course ponds. Once grass carp are stocked in a lake, it may take from two to five years for them to control nuisance plants. Survival rates of the fish will vary depending on factors like presence of otters, birds of prey, or fish disease. A lake will probably need restocking about every ten years. Success with grass carp in Washington has been variable. Sometimes the same stocking rate results in no control, control, or even complete elimination of all underwater plants. It has become the consensus among researchers and aquatic plant managers around the country that grass carp are an all or nothing control option. They should be stocked only in waterbodies where complete elimination of all submersed plant species can be tolerated.

Fish stocked into Washington lakes must be certified disease free and sterile. Sterile fish, called triploids because they have an extra chromosome, are created when the fish eggs are subjected to a temperature or pressure shock. Fish are verified sterile by collecting and testing a blood sample. Triploid fish have slightly larger blood cells and can be differentiated from diploid (fertile) fish by this characteristic. Grass carp imported into Washington must be tested to ensure that they are sterile. Because Washington does not allow fertile fish within the state, all grass carp are imported into Washington from out of state locations. Most grass carp farms are located in the southern United States where warmer weather allows for fast fish growth rates. Large shipments are transported in special trucks and small shipments arrive via air.

WDFW has the primary regulatory responsibility for stocking grass carp, however, other agencies have participated in or funded research on the use of grass carp for aquatic plant control and will continue to do so.

Grass carp effectively control some species of aquatic plants by feeding on them. The amount and rate of plant-biomass reduction is directly related to grass-carp feeding rates and the number of fish introduced (stocking rate). This feeding rate depends on several factors, including grass-carp age, water temperature, and dissolved oxygen level. Because grass carp prefer some species to others, the rate at which plant biomass is reduced also depends on the type of plants available for consumption.

Researchers at the University of Washington, who have been studying grass carp since 1983, do not recommend use of grass carp for Eurasian water milfoil control. This species is not a preferred food source and grass carp will consume most other aquatic plants before eating this species. Generally Eurasian water milfoil is consumed only when the waterbody is overstocked with grass carp and no other food source is left. This sometimes results in the total eradication of all submersed species in a waterbody. Grass carp should be stocked for Eurasian water milfoil management only if total eradication of all submersed species can be tolerated.

The University of Washington has developed a stocking model designed to maintain 30% to 40% of aquatic vegetation in a lake, for use as a management tool by the WDFW. University researchers recognize that each system should be evaluated to determine if stocking rates will meet the variety of lake management goals in Washington (Thomas et. al. 1990). In practice, Bonar et. al. found that only 18 percent of 98 Washington lakes stocked with grass carp at a median level of 24 fish per vegetated acre had macrophytes controlled to an intermediate level. In 39 percent of the lakes, all submersed plant species were eradicated.

Use of grass carp to control aquatic vegetation may result in adverse environmental impacts, with the potential for adverse impacts increasing if carp are stocked at inappropriate levels. Introduction of grass carp has been shown to reduce waterfowl abundance because grass carp and waterfowl prefer some of the same plant species and may compete with each other for sustenance. Because grass carp do not discriminate between target and non-target species, they may eliminate threatened or endangered plant species and/or alter wetland composition. Generally in Washington, grass carp do not consume emergent wetland vegetation or water lilies even when the waterbody is heavily stocked or over stocked. A heavy stocking rate of triploid grass carp in Chambers Lake in Thurston County resulted in the loss of most submersed species, whereas the fragrant water lilies, bog bean, and spatterdock remained at pre-stocking levels. A stocking of 83,000 triploid grass carp into Silver Lake, Washington resulted in the total eradication of all submersed species, including Eurasian water milfoil and Brazilian elodea. However, extensive wetlands in Silver Lake have generally remained intact. In southern states, grass carp have been shown to consume some emergent vegetation.

Grass carp can live up to 20 years or more and are very difficult to capture. Once grass carp are stocked into a waterbody, they can only be removed with very great difficulty. A rotenone bait was recently registered which can remove about 1/3 of the grass carp population. Fish are trained to feed at a pellet feeder. Once fish are trained a rotenone impregnated pellet is substituted and any fish consuming the bait are killed. However, remaining grass carp will not eat the bait. Pauley and Bonar evaluated seven techniques as methods of capture for grass carp in five Washington lakes. The capture methods included angling, pop-nets, lift nets, or traps in baited areas, angling in non-baited areas, heating the water in small areas to attract the fish, and herding fish into a concentration area and removing them with gill nets or seines. Herding fish into a concentrated area was the most effective technique when followed by angling in baited areas. As noted in the "methods" section, the WDFW has developed several conditions designed to mitigate some of the impacts identified above.

B. Plant Pathogens

Preliminary research has demonstrated that plant pathogens may be useful in the future control of aquatic vegetation in general and hydrilla and Eurasian water milfoil in particular. The establishment of inoculation strategies and inoculum thresholds and determination of the optimum time in the hydrilla and Eurasian water milfoil life cycle for initiation of infection are some topics requiring further research. The use of plant pathogens in conjunction with mechanical techniques or with organisms that physically damage plant tissues to provide inoculation sites may be particularly effective (Gunnar 1983). Recent research shows that using fungal pathogens in conjunction with low levels of aquatic herbicides is particularly effective in managing problem plants in the laboratory.

In the mid-eighties, a survey of the continental US for pathogens of Eurasian water milfoil was conducted on more than 50 waterbodies in 10 states (Zattau 1988). Bacteria isolates (462) and fungal isolates (330) were collected and maintained in pure culture. Lytic enzyme assays indicated that 36 isolates had potential as biocontrol agents; further assays indicated 5 fungal isolates, which may be particularly effective after additional study.

At this time, the most promising plant pathogen as a biological control agent for Eurasian water milfoil and hydrilla is the fungus Mycoleptodiscus terrestris (Winfield 1988). Extensive research on this fungus is underway in a number of laboratories and is described below. A rapid and devastating response by water milfoil to the fungus plus associated bacteria was observed in laboratory experiments; field experiments using only the associated microorganisms demonstrated that they may provide ecosites for the fungus by pitting the plant surface (Gunnar et al. 1988).

Further research on plant microbe interactions, the phase at which specific association may occur, and host specificity to two fungi was recently reported (Kees and Theriot 1990). Using a different approach, Stack (1990) constructed an epidemiological model that described the interaction of an aquatic plant host with a fungal plant pathogen using M. terrestris as the fungal agent and water milfoil as the host. Currently, Winfield (1990) is investigating the optimum shelf life and optimum level of M. terrestris inoculum needed for biocontrol of water milfoil. Finally, Andrews et al. (1990) recently assayed microbial colonization of Eurasian water milfoil by other fungi.

C. Herbivorous Insects

Further laboratory and field research needs to be conducted before herbivorous insects are available for use in aquatic vegetation control. Researchers from the US Department of Agriculture are currently surveying waters in China for potential biological control agents for hydrilla and Eurasian water milfoil (Balciunas 1990).

In British Columbia, researchers have observed several species of aquatic insects grazing on Eurasian water milfoil (Kangasniemi and Oliver 1983). The chironomid larvae *Cricotopus myriophylli* showed particular promise as a biological control agent. This insect effectively reduces the height of water milfoil plants by feeding on meristimatic regions. *C. myriophyllum* prefers *Myriophyllum spicatum* to *M. exalbescens* (a native water milfoil species). It is likely that *C. myriophylli* has spread downstream into the US through the Columbia River systems. Further research is needed to determine how to produce or sustain insect populations to attain effective control and to determine when the target plant is most vulnerable to attack. Development of techniques for adult mating and egg collection remains the most critical limitation to laboratory rearing.

In Vermont in the 1980's, several underwater insects significantly decreased Eurasian water milfoil populations in Brownington Pond. Researchers believe declines could be due to either two aquatic caterpillars (*Acentria nivea* = *A. niveus* and *Paraponyx sp.*) or an aquatic weevil (*Eurhynchiopsis lecontei*) (Sheldon 1990). The goal of future work is to evaluate the potential of one or more of the herbivorous insects to control water milfoil in other lakes.

Creed et al. added weevils (*Euhrychiopsis lecontei* Dietz) to *Myriophyllum spicatum* growing in laboratory aquaria. After harvest, it was determined that some of the aquaria also contained the aquatic caterpillar (*Acentria nivea),* so effects were attributed to herbivory in general. Both the weevil and caterpillar expose stem vascular tissue when feeding and this leads to the collapse of milfoil plants from the water's surface. The authors concluded that these herbivores do not have to remove considerable amounts of stem or leaf tissue in order to have a strong negative effort on milfoil. A collapsed plant sinks from the well-lit surface waters, sometimes carrying undamaged plants with it. Milfoil plants may not be able to get enough light for photosynthesis at these lower depths." From management viewpoint a collapsed plant is also off the surface and causing less impact to recreation and aesthetics.

A number of weevil augmentation experiments have been conducted where numbers of laboratory-reared weevils were introduced into lakes in Vermont and the Mid-West. Results have been mixed, with declines in Eurasian water milfoil in some waterbodies and no declines in others. Factors governing weevil densities are still unclear, but this method shows great promise as a biological control for Eurasian water milfoil.

Ecology is funding research at the University of Washington to evaluate whether the milfoil weevil will be a suitable control for Eurasian water milfoil in Washington. Unfortunately, densities of these naturally occurring native weevils in Washington appear to be much lower than the natural densities seen in other states. In comparison to states where weevils have been observed causing declines, Washington has cooler summer water temperatures.

D. Competitive Plants

Interspecific competition may be an effective aquatic plant control method in some situations. Further research is needed to determine specific conditions that enable native plant species to out compete invasive species such as purple loosestrife or Eurasian water milfoil.

In a 1986 study, researchers investigated the establishment of spike rush (Eleocharis coloradoensis) following chemical control (2,4-D) of water milfoil and showed mixed results (Gibbons et al. 1987). Spike rush was successful in surviving and reproducing in shallow areas planted with large, densely populated strips of cut sod. However, it was not successful in areas planted with strips composed of small wet plugs. Wave and water circulation patterns played a major role in transplant success.

E. Plant Growth Regulators

A new strategy for aquatic plant management involves the use of plant growth regulators. These compounds inhibit gibberellin synthesis, thereby inhibiting normal plant elongation. Early research in the laboratory resulted in a bioassay system using hydrilla and Eurasian water milfoil (Lembi et al. 1990). The bioassay suggests that gibberellin synthesis inhibitors uniconazol, flurprimidol, and paclobutrazol were effective in reducing plant height in aquatic systems but would have minimal adverse impacts on plant health (Lembi and Netherland 1990). (Note: Although these plant growth regulators are chemical control methods, they are included in the biological section because they are natural chemicals, not synthetic. They will require further research as will plant pathogens and herbivorous insects before they are ready for commercial use.)

F. Mitigation: Plant Pathogens, Herbivorous Insects, Competitive Plants, Plant Growth Regulators

As noted in the section describing biological methods and their impacts, additional research and licensing must be conducted before using plant pathogens, herbivorous insects, competitive plants, and plant growth regulators. Appropriate additional environmental review will be conducted once these methods become available. Also see ESA, Wetland and Sediment Mitigation for All Methods pages 11-14.

G. Grass Carp

Washington Department of Wildlife (WDFW) evaluates use of grass carp use in Washington (Ecology publication 00-10-045). Ecology has included grass carp as part of the integrated management approach of the Aquatic Plant Management Program, but all requests for grass carp stocking and planting permits should be made to WDFW.

1. Description

Grass carp, or the white amur, is a member of the minnow family. Grass carp can grow to 100 pounds in their native home range and can live for more than 20 years. Grass carp's natural habitat includes the large, swift cool rivers of China and Siberia. However, all grass carp in the United States are of Chinese origin (Pauley and Bonar). Female grass carp usually reach sexual maturity a year ahead of males, and the age of maturity depends on climate and nutrition. Female size at maturity is usually five to ten pounds, and the average ten to 15 pound female will produce 500,000 eggs each year. Water temperatures ranging from 59 - 63^{o} F trigger upstream migration to spawning grounds where grass carp spawn from April to August or September. Depending on temperature, eggs hatch in 16 to 60 hours, are free floating, and drift with the current. Newly hatched larvae absorb their yolk sacs at about one-third inch long and begin feeding on plankton; however, at one inch the fry start feeding on aquatic vegetation. Small grass carp prefer tender, succulent plants, and as the fish grow their preference range for aquatic plants broadens.

Grass carp have special teeth in their throats and a horny pad that enables them to cut, rasp, and grind aquatic plants which ruptures the plant cell membranes to allow digestion of plant material. Grass carp do not pull plants up by the roots like the common carp but eat from the top down without disturbing roots or sediment.

Intensive feeding begins at water temperatures above 68^{o} F, while feeding diminishes below 53^{o} F. Dissolved oxygen levels less than four ppm also reduce food intake by as much as 40 percent. Grass carp can consume up to 150 percent of their body weight per day when temperatures are above 77^{o} F but below 90^{o} F. Grass carp can survive a wide range of temperatures from freezing to 95^{o} F. They cannot survive in salt water but can migrate through brackish water. Growth rates of triploid grass carp were studied from four Washington lakes. Growth was highest in East Pipeline Lake where grass carp grew from an average of 144 grams to 6032 grams in approximately 4.3 years. In approximately the same time period, two size classes of grass carp grew from an average of 144 grams and 732 grams to 4419 grams in Keevies Lake and from an average of 144 grams to 3701 grams in Bull South Lake. In Big Chambers Lake, two size classes of grass carp grew from 223 grams and 282 grams to 2363 grams in approximately 1.3 years. Triploid grass carp growth rates in this study compared favorable to growth rates of grass carp from similar climatic areas and were equal or greater than growth rates of grass carp from their native range (Pauley and Bonar).

Grass carp were first brought to the U.S. in 1963 in Arkansas and other southern states. Fertile, diploid grass carp were stocked in initial treatments and because of the unknown potential impact to native fish and wildlife species, many states prohibited their use. They were declared deleterious exotic wildlife by WDFW in 1973. By the early 1980's, triploid grass carp, which are sterile, were being produced in the U.S. Researchers in regions where grass carp rapidly reach maturity have concluded that triploid fish are "functionally sterile". The hatching success of triploid x triploid crosses is less than 0.5 percent and all of these offspring are triploid. Normal diploid hatching success ranges from 40-50 percent (Pauley and Bonar). Triploid grass carp are developed when eggs of a normal (diploid) pair of grass carp are shocked chemically, with excessive pressure, or with heat. Triploid progeny alleviated the major concern about grass carp, reproduction in the wild.

In 1983, WDFW and Ecology initiated a long-term agreement through the University of Washington, funded in part by the US Army Corps of Engineers, US Fish and Wildlife Service, and the US Environmental Protection Agency. The goal of the study was to determine if triploid grass carp could be used safely and effectively to control nuisance levels of aquatic plants in Washington. Results of the studies are summarized under impacts due to grass carp; further reading includes Thomas and Pauley 1987, Thomas et al. 1990a, Thomas et al. 1990b. In 1990, WDFW produced a policy for introduction of grass carp to Washington lakes, ponds, or reservoirs less than or greater than five acres but without public access, and lakes, ponds or reservoirs with public access.

Toxicity. Use of grass carp is not expected to release toxic materials.

2. Impacts Due to Grass Carp

Earth

Sediments. Although European carp (a separate species) are known to increase the turbidity of water by disturbing sediments, grass carp do not pull up plants by the roots like the common carp but eat from the top down without disturbing roots or sediment. However in situations where grass carp have completely eliminated all submersed aquatic plants, grass carp will consume organic matter from the sediments, stirring them into the water column in the process. Removal of aquatic plants also allows wind mixing to suspend sediments into the water increasing total suspended solids and turbidity. Also see ESA, Wetland and Sediment Mitigation for All Methods pages 11-14.

Removal of plants by carp grazing may decrease the sedimentation rate in lakes, while waste from carp may increase sedimentation. Increased waste may elevate nutrient levels resulting in greater algal densities.

Water

Surface Water. Baseline data obtained by the University of Washington suggest that dense stands of aquatic macrophytes can have a significant effect on water quality in shallow lakes of the state (Pauley and Thomas 1987). The formation of a canopy can partition the water column into areas of contrasting water quality, with elevated pH, increased water temperature, and supersaturated dissolved oxygen concentrations within water milfoil mats. Beneath the surface canopy, water circulation and light penetration are restricted, while temperature and dissolved oxygen are reduced.

Dense beds of macrophytes can potentially modify the internal loading of phosphorus in lakes as a result of physical-chemical changes beneath plant beds, especially decreased dissolved oxygen. Removal of large dense beds of macrophytes by grass carp grazing may reduce sediment release of phosphorus.

Introduction of grass carp may reduce the aquatic plants from dense to moderate densities, which should improve water quality in part due to increased mixing of the water by wind. Total devegetation does impact water quality in Silver Lake where stocking grass carp resulted in total eradication of submersed vegetation, the benthic animal populations went from zero to a healthy community. This was attributed to increased wind mixing of the water column, which allowed oxygen to reach the formerly anoxic sediments. However, wind mixing also decreased water clarity by stirring sediments into the water column.

Bonar et. al. investigated the impacts of stocking grass carp on the water quality of 98 Washington lakes and ponds. They found that the average turbidity of sites where all submersed macrophytes were eradicated was higher (11 nephelometric turbidity units (NTU's) than sites where macrophytes were controlled to intermediate levels (4 NTU's) or not affected by grass carp grazing (5 NTU's). Most of this turbidity was biotic and not algal. Chlorophyll a was not significantly different between levels of macrophyte control.

Introduction of triploid grass carp into Keevies Lake and Bull Lake in Washington resulted in a reduction of surface cover and biomass of the aquatic macrophytes along with some improvements in the water quality. In areas dominated by floating leaved species, mean bottom dissolved oxygen increased from < 1 mg/liter to > 3 mg/liter. Mean conductivity increased from around 30 to 90 *m siemens*, and was associated with higher ion concentrations, primarily calcium which increased from around 2 mg/l to 4 mg/l. In areas dominated by submergent species, surface pH was reduced to <10, surface dissolved oxygen decreased from >20 mg/l to around 10-15 mg/l and mean bottom dissolved oxygen increased from 2.0 mg/l to 4.5 mg/l.

If aquatic plants are rapidly eliminated, the influx of nutrients from grass carp feces could result in substantial changes in water chemistry, phytoplankton densities (especially cyanobacteria, i.e., blue green algae), and bacteria levels (Pauley and Thomas 1987).

Water Chemistry. Low concentrations of dissolved oxygen beneath plant canopies can in some cases lead to the release of phosphorus from the sediment into overlying water. The most important change in redox in natural, stratified sediment-water systems (where Fe^{+++} is most responsible for phosphorus fixation with O_2)

happens in the redox (Eh) range of 3.8-3.1, which corresponds to the reduction of $Fe(OH)_3$ to Fe^{++}. Consequently, phosphorus is released from the sediment into overlying water. Such low values have been observed below dense beds of aquatic vegetation in Washington lakes. (Detailed descriptions of dissolved oxygen changes with depth in Eastern and Western Washington lakes with and without grass carp can be found in Pauley and Thomas 1987, Thomas et al. 1990a, and Thomas et al. 1990b.)

Public Water Supplies. Grass carp introduction would have no effect on public water supplies beyond effects described under Surface Water.

Plants

Habitat. Grass carp have been used successfully to control certain species of aquatic plants around the world (Ecology publication 00-10-045). They prefer some species of plants and will not consume others. Two types of aquatic plant control are desirable with grass carp in Washington:

1. Total and rapid eradication of plants where water flow and navigation are important (an example is an irrigation system where water delivery is more important that habitat), and

2. Slow reduction of plants to intermediate levels to enhance fish production and water dependent recreation.

Reaching the above goals will depend both on the stocking rate (number of fish added to the lake) and the knowledge of feeding preferences of grass carp on aquatic vegetation.

Pauley and Bonar performed experiments to evaluate the importance of 20 Pacific Northwest aquatic macrophyte species as food items for grass carp. Grass carp did not remove plants in a preferred species-by-species sequence in the multi-species plant communities. Instead they grazed simultaneously on palatable plants of similar preference before gradually switching to less preferred groups of plants. The relative preference of many plants was dependent upon what other plants were associated with them. The relative preference rank for the 20 aquatic plants tested was as follows: *Potamogeton crispus*= *P. pectinatus*> *P. zosteriformes*>*Chara* sp.= *Elodea canadensis*=Thin-leaved *Potamogton* > *Egeria densa* (large fish only) > *P. praelongus*=*Vallisneria americana* > *Myriophyllum spicatum* >*Ceratophyllum demersum*>*Utricularia vulgaris* > *Polygonium amphibium*> *P. natans* > *P. amplifolius* > *Brasenia schreberi* = *Juncus* sp. > *Egeria densa* (fingerling fish) > *Nyphaea* sp > *Typha* sp. > *Nuphar* sp. Researchers also demonstrated that feeding rates of triploid grass carp on four macrophyte species increased at higher water temperatures.

In field tests, investigators determined that many plant species less desirable to humans (such *as M. spicatum*, *E. canadensis*,) over winter vegetatively and are able to grow significantly in spring when water is less than 18^{o} C. Consequently, when the grass carp's body temperature raises enough to feed, it has to remove a large standing crop of the above macrophytes before it can control their re-growth (Pauley and Thomas 1987).

Plant species in lakes exhibit variability in growth patterns that affect the ability of grass carp to control them. For example, broadleaf communities tend to peak late in the growing season when ambient water temperatures are higher, which may help grass carp to control these species more effectively. In contrast, the maximum biomass of filamentous submerged communities tends to occur earlier in the season before carp metabolism is sufficient to control it.

University of Washington researchers investigated effects of grass carp introduction on five Washington lakes, two west of the Cascades and three on the eastern side of the mountains (Thomas et al. 1990b). In western Washington lakes dominated by *Brasenia schreberi* and *Potamogeton natans* declined after grass carp introduction, and increased the total amount of open water. In the eastern Washington lakes which were dominated by *Elodea canadensis*, *P. pectinatus*, *Myriophyllum sibericum*, and *Ceratophyllum demersum*, *P. pectinatus* was removed after grass carp stocking and the amount of open water increased in all sites. When stocked for lake management, grass carp usually show the most significant impact three to five years following introduction.

Bonar et al investigated the effects of grass carp on aquatic macrophyte communities and water quality of 98 Washington lakes and ponds stocked with grass carp between 1990-1995. Noticeable effects of grass carp on macrophyte communities did not take place in most waters until two years following stocking. After two years, submersed macrophytes were usually either completely eradicated (39 percent of the lakes), or not controlled (42 percent of the lakes). Control of submersed macrophytes to intermediate levels occurred in 18 percent of lakes at a median stocking rate of 24 fish per vegetated acre.

Ecology does not support removal of non-noxious emergent (wetland) species except in controlled situations where the intent is to improve low quality (Category IV) wetlands and in situations where wetlands have been created for other specific uses such as stormwater retention.

Grass carp eat native species as well as exotic species of aquatic vegetation; thus use of grass carp may result in positive or negative impacts depending on vegetation in the specific waterbody. Another potential negative impact of grass carp introduction would be destruction of perimeter or riparian emergent vegetation. Loss of perimeter vegetation may increase shoreline erosion and decrease the treated water body's value as wildlife habitat.

Animals. Grass carp are omnivorous in the juvenile stage and will eat small invertebrates once they are beyond the egg sac stage. When grass carp are larger than one inch they convert to herbivory. Since grass carp are stocked at sizes over eight inches long, they are not expected to graze invertebrates in Washington lakes. Additionally, triploid grass carp are sterile, thus eliminating any chance of reproduction in the wild.

The greatest potential impact of grass carp introduction on invertebrates and vertebrates is the removal of the majority of the plant community. Major changes in aquatic vegetation will affect invertebrate populations that depend on it; however, no negative impacts to fish have been documented in studies in Washington (Ecology publication 00-10-045). Under some circumstances, complete plant removal is detrimental to largemouth bass populations, but may be beneficial to salmonids. Populations of small centrarchid fish are generally considered to become more vulnerable to predation as aquatic macrophyte densities decrease, and populations of piscivorous centrarchid fish become highest at intermediate densities of aquatic plants (Wiley et al. 1984, in Thomas et al. 1990a). At extremely high densities of grass carp where aquatic macrophytes have been totally eradicated, growth and abundance of centrarchid game fish populations have been poor (Thomas et al. 1990a).

Pauley et. al. studied the impacts of triploid grass carp grazing on the game fish assemblages of Pacific Northwest lakes. Fish samples were taken from Keevies Lake and East Pipeline Lake in Washington in 1885, 1986, 1988, and 1990, and from Devils Lake, Oregon in 1986, 1987, and 1988. Age, length, and weight data were collected for several species of fish including largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), pumpkinseed sunfish (*Lepomis gibbosus*), bluegill sunfish (*Lepomis macrochirus*), yellow perch (*Perca flavescens*), and brown bullhead (*Ictalurus nebulosus*). In Devils Lake, largemouth bass, bluegill sunfish, and yellow perch exhibited post-stocking declines after grass carp were introduced. East Pipeline Lake exhibited no effect on the largemouth bass subsequent to grass carp stocking. Keevies Lake exhibited declines of largemouth bass after grass carp were introduced. Pauley et. al. attributed the declines of bass and other fish in Devils Lake to increased angler access while the bass declines in Keevies were thought to be due to natural variation. In neither case were grass carp thought to be responsible for any game fish population changes.

Although effects of plant removal on largemouth bass (*Micropterus salmoides*) and sunfish (*Lepomis* spp.) have been studied after introduction of grass carp, the relationship between macrophytes and these fish is poorly understood (Thomas et al. 1990a). It is unlikely that grass carp would physically disturb spawning bluegill sunfish by causing turbidity and siltation in spiny-ray spawning areas. It is also unlikely that grass carp stocked at sizes over 8 inches will be potential prey for largemouth bass. Indirectly, removal of aquatic macrophytes is assumed to increase susceptibility of most forage fish to game fish predation.

Grass carp have been diagnosed with over 100 diseases and parasites, 29 documented in the US. The top 11 pathogens are already present in Washington or are not considered dangerous, with the exception of the Asian tapeworm (*Bothriocephalus opsarichthydis*). Importation of the tapeworm will be avoided by shipping only grass carp that are greater in length than 8 inches (Ecology publication 00-10-045). According to WDFW, Tripoid grass carp may not be imported into Washington without being disease-free certified and may not be stocked unless they are 10 inches in length.

Grass carp may, and do, compete for certain kinds of vegetation with waterfowl. The WDFW has a process whereby all programs review applications before SEPA is conducted. If the wildlife biologist determines the grass carp planting will impact waterfowl in that area, the application is denied, and the applicant is advised as to other options that are available for aquatic plant control.

Grass carp are riverine fish and have the urge to move into flowing water. Therefore all inlets or outlets need to be screened (and the screens maintained) to keep grass carp from migrating up or down stream. Screening in a waterbody with anadromous fish runs is problematic. It is difficult and expensive to design a screen that will allow salmon or steelhead passage while restricting the movement of grass carp. Grass carp grow to be large athletic fish fully capable of negotiating fish ladders. In fact, in 1996 presumably escaped grass carp were observed migrating past several lower Columbia and Snake River dams (Loch and Bonar). Generally WDFW will not allow the stocking of grass carp into systems that support anadromous fish runs. However, there have been exceptions such as Silver Lake in Cowlitz County.

Threatened and Endangered Species. Introduction of grass carp has the potential to affect submersed and emergent plant species federally listed as rare, threatened or endangered. Applications for grass carp stocking for each specific site should include a review of the rare, threatened, or endangered plant species listed by US Fish and Wildlife and of "proposed sensitive" plants and animals listed by Washington State Natural Heritage Data System.

Water, Land and Shoreline Use

Aesthetics. Use of grass carp may result in decreased vegetation, which may be viewed as either a positive or adverse impact on aesthetics, depending on the attitude of the observer, and the amount and species of plant removed.

Recreation. When stocked at proper rates into lakes with dense macrophyte beds, grass carp will improve swimming, fishing, and boating. If stocked at too high a rate, grass carp could potentially decrease fish habitat and thus negatively affect fishing. Negative impacts on aquatic vegetation used by waterfowl are expected; decreased waterfowl populations would negatively affect hunting. Grazing by grass carp is expected to improve recreational facilities used for swimming, fishing, and boating by decreasing unwanted aquatic vegetation.

Navigation. Effects of grass carp on transportation are expected to be minor. Grazing of dense macrophyte beds by grass carp may improve navigation, most likely for recreational boating.

Agriculture. No impacts on agricultural crops are expected with grass carp introductions. Grass carp are currently used successfully in irrigation canals in California, Arizona, and Alberta. At this time, grass carp are proposed for use in manmade irrigation and power canals in Washington at the expense of the property owner.

3. Mitigation, Grass Carp

Communications. For lakes, ponds, or reservoirs less than five acres and without public access, triploid grass carp may be planted at the expense of the property owner. A list of all property owners with land adjacent to the water and their opinion of the proposed introduction must be provided to WDFW. Lakes, ponds, or reservoirs with public access may be stocked with grass carp if a professional lake restoration feasibility assessment or an integrated aquatic vegetation management plan is completed. Both types of planning efforts must include public input and involvement (Ecology publication 00-10-045).

Permits. WDFW requires a game fish planting permit before allowing grass carp into a pond or lake. Ecology can fund some grass carp projects through Phase II Lake Restoration Grants or loans, or by the Aquatic Weeds Management Fund if grass carp are identified as a management option in an integrated aquatic plant management plan for that waterbody. If inlets or outlets require screening prior to the introduction of grass carp, a HPA also needs to be obtained from WDFW for the screening work. . Department of Natural Resources Natural Heritage Program must be contacted for assessment of threatened and endangered species before WDFW will permit the stocking of grass carp.

Water Quality, Plants, and Animals. Impacts of grass carp on water quality, plants, and animals are continuing to be assessed. Potential impacts from grass carp include changes to water chemistry, increased phytoplankton densities resulting from an influx of grass carp feces, and loss of desirable or unique plant species and/or excessive loss of plant biomass. Because waterfowl depend on aquatic plants for food, loss of plant biomass may adversely affect waterfowl. Information regarding impacts to fish populations and wetlands is equivocal and warrants additional research. As the lead-permitting agency for stocking grass carp, WDFW has developed policies designed to reduce or prevent some potential impacts. A copy of this policy and other relevant information is included in Ecology publication 00-10-045.

WDFW requires documentation from the US Fish and Wildlife Service that fish to be planted are certified disease-free triploid grass carp. A professional lake restoration feasibility assessment must be conducted to address cultural resources, water quality, restoration feasibility, and public involvement as well as a SEPA checklist for all applications requesting permission to stock grass carp. In evaluating each of these checklists, WDFW can assess potential impacts to specific water bodies and condition permits to reduce potential impacts. Because most permits issued to date have been for small, privately owned lakes with impacts identified as being minimal, the responsible official has determined that DNSs were appropriate. Where shoreline permits, or other local permits are required, local government may be the lead agency.

Impacts from grass carp depend on characteristics of the waterbody to be stocked, the stocking rate, the plant community, plant density, and the knowledge of feeding preferences of grass carp. WDFW generally permits the introduction of grass carp mostly into small, private ponds. However, their policy does not contain a waterbody size threshold and the agency has received permit applications for larger waterbodies. WDFW's policy states that Ecology must approve applications to waterbodies with public access, which may affect the number of applications to larger systems. WDFW requires any outlets and inlets to be screened so that grass carp do not move into areas where there are anadromous or resident fish. The need to maintain these screens is critical. Otherwise, screening may fail if not monitored, cleaned and replaced, if necessary.

Limiting permits to small, privately owned ponds tends to reduce the scope of impacts, as well as the seriousness of impacts such as potential cumulative effects on wildlife, particularly waterfowl. Impacts may be reduced by assessing habitat needs, surveying existing habitat in a general area, evaluating potential cumulative impacts of habitat reduction in waterbodies in that area, and preserving habitat adequate to meet the needs of waterfowl. Besides a planting permit, all grass carp applications must go through SEPA. A wetland disclosure statement is required if the waterbody is a natural pond or lake. WDFW reviews grass carp applications and approves them before they are sent out for environmental review. If the planting project will impact wildlife, or cause habitat concerns, the application will be denied, rather than sent out for SEPA review. Also see ESA, Wetland and Sediment Mitigation for All Methods pages 11-14.

References

Andrews, J., R. Harris, C. Smith, and T. Chand. 1990. Host specificity of microbial flora from Eurasian water milfoil. Technical Report A-90-3. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Balciunas, J. 1990. Biocontrol agents from temperate areas of Asia. Proceedings, 24th Annual Meeting, Aquatic Plant Control Research Program. Miscellaneous Paper A-90-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Broch, E., J. Ahl, and J. Loescher. 1984. The distribution and abundance of aquatic macrophytes in lakes of the Colville Indian Reservation. Unpublished report, Washington State University. Pullman, WA.

Creed, R.P., Sheldon, S.P. and Cheek, D. M. 1992. The effect of herbivore feeding on the buoyancy of Eurasian water milfoil. The Journal of Aquatic Plant Management 30: 75-76.

Gibbons, M. V., H. L. Gibbons, and R. Pine. 1987. 1986 Lake Osoyoos demonstration project. Prepared for Washington Department of Ecology.

Gunnar, H. 1983. Biological control of Eurasian water milfoil. Proceedings, 17th Annual Meeting, Aquatic Plant Control Research Program. Miscellaneous Paper A-83-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Gunnar, H., Y. Limpa-Amara, P. Weilerstein. 1988. Field evaluation of microbiological control agents on Eurasian water milfoil. Technical Report A-88-1. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hardin, S., R. Land, M. Spelman, and G. Morse. 1984. Food items of grass carp,, American coots, and ring-necked ducks from a Central Florida lake. Proceedings of the Annual Conference of the Southeast Association of Fish and Wildlife Agencies. 38:313-318.

Kangasniemi, B. and D. Oliver. 1983. Chironomidae (Diptera) associated with Myriophyllum spicatum in Okanogan Valley lakes, British Columbia. Canadian Entomologist. 115:1545-1546.

Kees, S., and E. Theriot. 1990. Attachment of plant pathogens to submersed aquatic plants. Proceedings, 24th Annual Meeting, Aquatic Plant Control Research Program. Miscellaneous Paper A-90-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Lembi, C., T. Chand, and W.C. Reed. 1990. Plant growth regulators effects on submersed aquatic plants. Proceedings, 24th Annual Meeting, Aquatic Plant Control Research Program. Miscellaneous Paper A-90-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Lembi, C. and M. Netherland. 1990. Bioassay of plant growth regulator activity on aquatic plants. Technical Report A-90-7. US Army Engineer Waterways Experiment Station, Vicksburg, MS. 16 pp.

Pauley, G. and G. Thomas. 1987. An evaluation of the impact of triploid grass carp (Ctenopharyngodon idella) on lakes in the Pacific Northwest. Third Progress Report to Wash. Dept. Wildlife and Wash. Dept. Ecology. Wash. Coop. Fishery Research Unit, Univ. Washington, Seattle, WA. 455 pp.

Schoof, R. A. 1991. Correspondence to Washington Department of Ecology.

Sheldon, S. 1990. A sudden decline of a Eurasian water milfoil population in Brownington Pond, Vermont. Proceedings, 24th Annual Meeting, Aquatic Plant Control Research Program. Miscellaneous Paper A-90-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Stack, J. 1990. Development of the fungal agent Mycoleptodiscus terrestris for the biological control of Eurasian water milfoil (Myriophyllum spicatum L.). Proceedings, 24th Annual Meeting, Aquatic Plant Control Research Program. Miscellaneous Paper A-90-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Thomas et. al. 1990. An Evaluation of Triploid Grass Carp (Ctenopharyngodon idella) Grazing on Ponds and Lakes of the Pacific Northwest. University of Washington.

Thomas, G., J. Frodge, S. Bonar, and G. Pauley. 1990b. An evaluation of triploid grass carp (Ctenopharyngodon idella) grazing on ponds and lakes of the Pacific Northwest. Fifth Progress Report to Wash. Dept. Ecology and Wash. Dept. Wildlife. Wash. Coop. Fish and Wildlife Research Unit, Univ. Washing, Seattle, WA.

Thomas, G., S. Thiesfeld, S. Bonar, J. Frodge, and G. Pauley. 1990a. Short-term effects of triploid grass carp (Ctenopharyngodon idella) on the plant community, fish assemblage, and water quality of Devils Lake, Oregon. Report to the Devils Lake Water Improvement District. Wash. Coop. Fish and Wildlife Research Unit, Univ. Washington, Seattle, WA. 112 pp.

Tucker, B.B., 1980, Diquat Environmental Chemistry: Summary and Literature References List.

Winfield, L. 1988. Biological control of Eurasian water milfoil with Mycoleptodiscus terrestris. Proceedings, 22nd Annual Meeting, Aquatic Plant Control Research Program. Miscellaneous Paper A-89-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Winfield, L. 1990. Biological control of Eurasian water milfoil. Proceedings, 24th Annual Meeting, Aquatic Plant Control Research Program. Miscellaneous Paper A-90-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Wiley, M., R. Gorden, S. Waite, and T. Powless. 1984. The relationship between aquatic macrophytes and sport fish production in Illinois ponds: a simple model. North American Journal of Fisheries Management. 4:111-119.

Wisconsin DNR. 1990. Chemical Fact Sheet.

Zattau, W. 1988. A survey of the continental United States for pathogens of Eurasian water milfoil. Technical Report A-88-3. Department of the Army, Waterways Experiment Station, Vicksburg, MS. 31 pp.

Section VII. Use of Chemicals Only as an Alternative

A. Introduction to Chemical Control Methods

Under this alternative, Ecology would permit aquatic herbicides that do not cause unreasonable adverse impacts, including prolonged water use restrictions.

This section updates the "Use of Chemicals Only" sections of the 1980 Aquatic Plant Management Environmental Impact Statement and its 1992 Supplement and adds new data on diquat dibromide.

The information on diquat reviewed in this SEIS is brief, concise and not overly technical. Analysis and evaluation of diquat is based primarily on technical review found in the risk assessments supporting them and is simply summarized herein. The detailed technical supporting information is referenced in the respective risk assessment Appendix A.

The supportive risk assessments follow the structural organization that the Environmental Protection Agency (EPA) Office of Pesticide Programs uses to develop data requirements for the registration of pesticides. They include basic data on the physical and chemical properties of the herbicide, the behavior of the compound in the environment, and its toxicity to non-target organisms. These data contribute to the quantification of hazard. The suite of data developed in this manner have been evaluated under the use scenarios (the labeled directions for use) in order to determine exposure. Then, the risk assessment process combines the hazard and exposure data to determine the magnitude, if any, of risks for the use of the products when used according to the label. Where risks are identified, seasonal timing, rate or use limitations, or other criteria are suggested as possible risk mitigation criteria.

The herbicide review in this section is organized into:

- The registration status,
- The physical and chemical characteristics of the herbicide's active ingredients, and where relevant, the characteristics of the end use products,
- A review of potential environmental and human health impacts from exposure to the use of the compound. This section combines the assessment of the effect data with the behavioral properties of the compounds in order to quantify risk for non-target organisms.
- The final part quantifies hazard or risk for the use of the products when used according to the label and proposes mitigation measures for each aquatic herbicide. Where risks are identified, seasonal timing, rate or use limitations, or other criteria are suggested as possible risk mitigation criteria, and
- A reference to the supporting appendix or a complete bibliography of citations is presented at the end the herbicide review.

B. Types of Herbicides

Herbicides are selected for use based on impacts, availability, cost and effectiveness of control. Effectiveness of an aquatic herbicide is primarily dependent on its mode of action and suitability for the targeted aquatic plant. Aquatic plants are categorized as submerged, emergent or floating, indicating the way the plant typically grows. Plants growing only below the water line are submerged, those growing from below the water line to above the waterline are emergent, and those growing on the surface of the water, sometimes un-rooted, are floating. Pre-emergent and post-emergent weed control refers to whether control measures are taken prior to or after germination of first growth of the plant. Herbicides used for aquatic weed control fall into one or more general categories:

- Contact herbicides are plant control agents that are used in direct contact with foliage and destroy only contacted portions of the plant.
- Systematic herbicides are applied to foliage and/or stems and are translocated to roots or other portions of the plant, resulting in death of the entire plant.
- Broad-spectrum herbicides kill most if not all plants with the appropriate dosage.
- Selective herbicides only kill certain plants or families of plants.
- Broadleaf herbicides generally kill dicot plants with broad leaves.

C. Registration Requirements

In order to register an aquatic herbicide for use with the EPA, the active ingredient and its formulations must be tested for toxicity birds, mammals and aquatic organisms, physical chemistry, environmental fate and effects on ground water. Additional work must be done to demonstrate expected magnitude of residue on edible products and residues in water. After these data are generated, they are submitted to EPA for review. If the reviews find that the product does not pose significant risk to humans, livestock, or wildlife and has a favorable environmental persistence and degradation profile, a registration will be granted. With that registration the manufacturer has permission to sell the product in the United States. However, each state may have its own separate registration process which may be more stringent than the EPA's registration process. Washington State's registration procedure follows EPA registration. It requires that the applicant submit a copy of the market label and a copy of the confidential statement of formula. Washington State Department of Agriculture reviews these submittals for compliance with state and federal requirements. If these requirements are filled the product will usually be registered unless it presents an unusual hazard to the environment. A more detailed description of the registration process is given in the registration status section of the risk assessments located in Appendix A.

D. Tank Mixes, Inerts and Surfactants

In general, tank mixes are not permitted in the state of Washington for the control of aquatic weeds in public waterways. This is because risk assessment information is not available on mixtures of herbicides.

Ecology must approve the specific formulation as well as the active ingredient. "Inert materials" in a formulation may interact with the pesticide to give antagonistic, additive, cumulative or synergistic effects against target plants (aquatic weeds and algae) and non-target fish and aquatic invertebrates. For example, endothall acid is considerably more toxic to rainbow trout and bluegill sunfish when certain "inerts" are added, possibly due to a synergistic effect (Ecology publication 00-10-044).

If surfactants are used, care should be taken to use those registered for aquatic uses since they have potential toxicity to fish. Thickening agents like Polysar® or Nalquatic® are used in other states to control drift with liquid endothall products that are applied to floating weeds and may also allow subsurface applications to sink more deeply into the water column where they can be most effective. However, these two adjuvants are not registered for use in Washington State and therefore are not allowed for distribution here (Ecology publication 00-10-044 and Personal Communication with Wendy Sue Wheeler, WSDA, May 30, 2000).

E. General Permit Conditions for Aquatic Herbicides

Several strategies are available for avoiding or minimizing potential impacts associated with use of aquatic herbicides. Some mitigation measures are applied generally to all proposed herbicide treatments because there are impacts common among various treatments while some are tailored to each specific proposal and/or herbicide proposed for use. The recommended mitigation in the following impact sections on diquat supplies the general and special conditions found in Ecology's aquatic plant control permits. Permit conditions are also supplemented by public notice procedures. Links and contacts to the permit application are available in Appendix C.

F. Diquat

1. Registration Status

Diquat initially received Federal registration for control of submersed and floating aquatic weeds in 1962 and was recently re-evaluated through EPA's Registration Eligibility Decision (RED) process, completed in July, 1995 (for on-line copies see http://www.epa.gov/oppsrrd1/REDs/0288.pdf.)

The WSDA has approved diquat for use under several labels, but the only approved formulation for use in public waterways is Reward® Landscape and Aquatic Herbicide (EPA registration no. 0182-404, by the registrant Syngenta, formerly Zeneca). This product contains 37.3% active ingredient (3.73 pounds diquat dibromide/gallon) which is equal to 20% cation equivalents (2.0 pounds diquat cation/gallon).

Ecology evaluated diquat in the 1992 SEIS and determined it would not be permitted for use in Washington waters until critical information was available. Additionally, endothall, a less toxic contact herbicide, was available for use. Specifically, the research needs and concerns for diquat identified in the 1992 SEIS included:

1. Mutagenic effects – the 1992 SEIS found conflicting data.
2. EPA's carcinogenicity study was still pending in 1991.
3. Long-term low-level exposure caused corneal opacity and cataracts in animals.
4. A sub-chronic oral response dose (RfD) was not available for diquat in 1991.
5. Diquat was determined to be about ten times more toxic than endothall on a mg/kg body weight basis (PTI Environmental Services, 1991).

The 2002 EIS shows: A considerable amount of research was done from 1992 to the present to support the continuing registration of aquatic herbicides and algaecides containing diquat, and the above concerns have been further investigated (respectively).

1. Diquat has genotoxic potential at dose levels associated with cellular toxicity. However, due to diquat being highly ionized and having poor lipid solubility, transport across cell membranes at low dose levels may reduce the potential to cause cellular genetic injury or damage (Appendix A, Sect. 5, p.18).
2. The carcinogenic potential of diquat was evaluated by the Health Effects Division Reference Dose (RfD)/Peer Review Committee. The committee concluded that diquat was not a carcinogen and classified the chemical in Group E, evidence of non-carcinogenicity for humans (EPA, 1995).
3. The chronic or lifetime exposure effects from diquat have been evaluated in the mouse, rat and dog. The findings from the investigations are consistent in that long-term exposure at high-and mid-diquat dose levels primarily resulted in the development of cataracts. However, a review of the medical and scientific literature for human exposure did not provide any findings or reports

that chronic diquat exposure occurs when the product is used according to label directions (Appendix A, Sect. 5, p.15).

4. The exposure and risk assessments associated with diquat use as an aquatic herbicide are presented in Tables 6-13 of Appendix A, Section 5, p. 40. The tables cover persons engaged in swimming, drinking both potable and treated surface water and eating fish from water where the chemical has been applied. The different types of daily exposures and risk assessments were calculated for both individual and combined scenarios. Based on the estimated diquat exposures, the risk assessments were determined by the margins of safety (MOS) and the % of the reference dose (RfD). The diquat calculations were conducted using the label maximum use-rate of 2 pound cation/surface acre. However, a study done in Washington State (Serdar, 1997) found that concentrations of diquat resulting from a treatment in Steilacoom Lake did not comply with the current Reward® label restriction for drinking water (3 days) based on a maximum allowable level of 10 ug diquat/L.
5. The RfD is the maximum allowable daily dietary intake of a chemical residue which will not result in an adverse effect. It is calculated by dividing the No Observed Effect Level (NOEL) from a mammalian chronic feeding study by a safety factor. Comparing the relative toxicity of two active ingredients by using their RfD's is only of value when looking at the direct consumption of the parent compound through ingestion over an extended time period. Therefore, this comparison is not relevant to exposure and risk from aquatic herbicides used in an aquatic environment (Shaw, 2002).

Diquat is currently being proposed for use under certain conditions specified in an aquatic pesticide discharge permit.

2. Description

Diquat dibromide [6,7-dihydrodipyrido(1,2-a:2',1'-c) pyrazinediium dibromide] is a dipyridylium compound related to quaternary ammonium compounds (Crafts 1975 in Westerdahl and Getsinger 1988). All diquat formulations are liquid bromine salts. Diquat is a dark brown, odorless liquid of molecular weight 344, and is water-soluble at 700 mg/l in water at 20 degrees Celsius (EPA, 2002).

Diquat is a non-selective contact herbicide for aquatic plants and algae and a desiccant, defoliant and growth regulator for seed crops. It is rapidly absorbed by green plant tissues, which are killed on exposure to light. It possesses some systemic properties. Its mode of action is described as a photosynthetic electron flow diverter. Compounds in this group result in rapid disruption of cell membranes and very rapid kill. The dipyridyliums penetrate into the cytoplasm, cause the formation of peroxides and free electrons (light is required) which destroy the cell membranes almost immediately. Rapid destruction of cell membranes prevents translocation to other regions of the plant (EPA, 1995; Purdue, 2000; Worthing, 1991).

Diquat is formulated as a solution in water. The primary concentrated end-use product for aquatic use is Reward® Landscape and Aquatic Herbicide (EPA Reg. No. 10182-404). Reward® may be used to control a number of submerged species as well as several species of emergent weeds. Water milfoil (*Myriophyllum* spp.), elodea (*Elodea* spp.), hydrilla (*Hydrilla verticillata* spp.) and water hyacinth (*Eichhornia crassipes*) are among the plants listed for control by a prescribed application rate on the label. Diquat is not typically used for algae control and most species of algae are not affected strongly by diquat with the exception of filamentous algae. Because the action of diquat is dependent on sunlight, control of plants above water occurs more quickly (within ten days) than does control of plants under water (30 to 40 days). Diquat is absorbed through the cuticle of the leaf and acts by interfering with photosynthesis, creating rapid inactivation of cells and cellular functions through the release of strong oxidants. Phytotoxic effects of diquat on above-surface foliage can be seen within one hour of treatment in bright sunlight.

Diquat is applied with surface spray in early season and with subsurface injection when submersed weeds have reached the water surface. In firm sandy-bottom lakes with slow moving water, diquat is placed one to two inches above the lake bottom with weighted trailing hoses.

Degradation Products. While photolysis may be important for the degradation of diquat in shallow, non-turbid waters with low levels of weed growth, it is likely that microbial degradation, adsorption into target plants, and adsorption onto sediment and seston (suspended matter) as well as dilution from untreated waters are the major modes of dissipation in the field.

Persistence. Diquat is dissipated rapidly from the water column and is retained on sediment for very long periods of time. In the absence of aquatic weeds, diquat has a very long half-life. The half-life for the aerobic aquatic metabolism study is >31 days and the half-life from the anaerobic study is much longer than 9 months (Appendix A, Section 3, p.19). However, most outdoor studies report that diquat is removed rapidly from the water column with a half-life ranging from <1 day to ~ 4 days. At sites where diquat dissipation from water is rapid, a combination of factors is involved. These factors may include sediment with high amounts of montmorillonite or bentonite clay, seston (suspended matter) containing suspended sediment with a high proportion of clays in them, the presence of phytoplankton which may adsorb diquat to high levels and the presence of aquatic macrophytes that may also adsorb diquat. Diquat is also subject to photochemical degradation. Sorption and microbial degradation are the major fate processes affecting diquat persistence (Simsiman et al. 1976).

Since persistence in water is dependant on the presence of suspended solids, detection can range from <1 day to ~ 35 days. The concentration of diquat in sediment usually starts out low (<0.5 ppm a.e.) but can build up over time as treated aquatic weeds decay and release diquat back into the water column or additional treatments occur. However, after the aquatic weeds die and release diquat back into the water between the 24^{th} and 56^{th} day, concentrations can rise to as high as 37 ppm c.e. Furthermore, dissipation from the sediment can be slow with 24 ppm c.e. remaining in the sediment 160 days after application. The half-life of diquat on these treated sediments has been estimated to be greater than 160 days at many of the treatment sites. Therefore, the persistence of diquat in sediment can be longer than four years with sediment concentrations remaining higher than 1.7 ppm c.e after treatment with 0.27 lbs/acre (Appendix A, Section 3, page 17).

Recommended Mitigation:

1. Treatment with diquat is restricted to submersed plants, floating plants and filamentous algae.
2. A two meter buffer from the shoreline must be used except for noxious weed control efforts due to non- target exposure and persistence in soil.
3. Diquat is not allowed for use on emergents in drainage ditches, wetlands or riparian areas due to its long-term persistence in soil unless otherwise authorized. Use is limited because:

   - diquat is moderately to highly toxic to birds and amphibians respectively as well as to some invertebrates;
   - diquat is a contact herbicide;
   - depending on the target plant there are effective herbicides that are less toxic and less persistent; and
   - diquat's persistence in sediment and soil has unknown impacts to the environment over time.

Diquat cannot be applied to the same area of a waterbody more than twice per growing season. Repeat treatments should be minimized by follow-up Integrated Pest Management (IPM) methods to herbicide applications.

Except for early infestation of noxious weeds, the second treatment and treatments thereafter are only allowed under an approved Integrated Aquatic Vegetation Management Plan.

Half-life. In studies conducted in Washington State, (Serdar, 1997) found that the half-life of diquat in the water column at Lake Steilacoom ranged from 2.1 days to 3.4 days. Lake Steilacoom was treated in its entirety (except for areas immediately around the inlet and outlet and in water more than 15 to 17 feet deep). Concentrations of diquat were highest in a treated embayment and in Chambers Creek (just below the dam) for the first three days after treatment at 0.13 ppm c.e. on June 5, 1996. Twenty-four hours after treatment, the concentration of diquat in the embayment was 0.087 ppm c.e. However, the concentration of diquat in the embayment dropped to 0.059 ppm c.e. three days after treatment. It is important to note that that concentration exceeded the label recommendation of a three day waiting period for drinking water. Concentrations of diquat were lower in open areas 300 feet off shore and within 300 feet of the mouth of Ponce de Leon Creek, which provides the dilution water for Lake Steilacoom. The concentration for the first three days after treatment at these sampling sites ranged from 0.033 to 0.057 ppm c.e. and did not vary significantly. By seven days after treatment, the concentrations of diquat in water had dropped to less than the drinking water standard (0.02 ppm c.e.) and by 12 days the highest concentrations of diquat ranged from 0.003 to 0.007 ppm c.e. Since the concentration of diquat in water exceeded the maximum contaminant level goal (0.02 ppm c.e.) for at least the first seven days after treatment, Serdar recommends that treated water should not be used for drinking, livestock watering, or irrigation for the first 14 days after treatment. Furthermore, some of the more susceptible invertebrates (like *Hyallella azteca*) and fish (striped bass) may be adversely impacted by the presence of diquat in the water column.

Typical Use. In addition to controlling water milfoil, diquat is known to be particularly effective against duckweed (*Lemna* spp.) elodea (*Elodea* spp.) and cattails (*Typha* spp*)*. Reward® is also labeled as an algaecide (Reward® LA label, 2000).

3. Environmental and Human Health Impacts

Air

Air quality. The vapor pressure of diquat dibromide is too low to be measured, thus there is no possibility of a vapor hazard (Valent U.S.A. Corporation 1989). Furthermore, little aerial drift or overspray is expected if label warnings are followed, and no aerial drift is expected when herbicide application is performed with subsurface applicator devices.

Recommended Mitigation:
No aerial applications permitted because impacts have not been evaluated.

Earth

Soils. Diquat tightly adsorbs to clay. A reaction between the double positively charged diquat cation and clay minerals present in sediments forms complexes with negatively charged sites on the clay minerals (Westerdahl and Getsinger 1988). Diquat may even insert into layer planes of expandable clay minerals such as montmorillonite. Diquat also binds to soils and sediments by incorporation into humus and by normal Langmuir-type (physical) adsorption onto organic matter and particles.

Diquat probably persists indefinitely when sorbed to soil particles. It has been shown to bind rapidly and tightly to some soil particles. The binding capacity of diquat may be variable depending on available particle sites, soil type, and other factors. Binding of diquat to sandy sediments might be as much as ten times slower than to clayey, silty, or loamy sediments (Ecology and Environment, Inc. 1991). In muck soils, it may take several days for diquat initially adsorbed onto relatively weak adsorption sites on organic matter to be transferred to the strong adsorption sites on clay minerals (Valent U.S.A. Corporation, 1989).

Diquat is not considered bioavailable to most microbes when bound to clay (Simsiman et al. 1976). Diquat is so firmly adsorbed to clay minerals that it can only be displaced by extremely rigorous treatments, such as boiling the soil with 12N - 18N sulfuric acid for several hours. This process destroys the clay structure and organic matter, thereby eliminating adsorption sites. However, Coats et.al. (1966) found that diquat treated soils were effective in inhibiting the growth of wheat seedlings depending on the soil type and how tightly bound the diquat was to that soil. On kaolinite clay, concentrations of diquat as high as 1,000 ppm c.e. inhibited the growth of wheat seedlings by approximately 40% and 50%, respectively. These concentrations are highly in excess of the concentrations that would typically be used to treat for terrestrial weeds (0.25 to 0.89 lbs a.i./ acre = 0.19 to 0.66 ppm a.i. = 0.10 to 0.35 ppm c.e. in the top 15 cm of soil). Therefore, wheat would probably not be affected if grown in soil that had previously been treated with diquat at standard application rates stated on the label. In the case of diquat, adsorption will bind the chemical so tightly that microorganisms cannot use it and non-target plant species will not typically be able to adsorb it when they are planted in plots previously treated with diquat. It has been estimated by Knight and Tolimson (1967 in Simsiman et al, 1976) that over 10,000 kg/ha of diquat would be required to exceed the typical strong absorbance capacity of a typical sandy clay loam agricultural soil.

There is no major degradation of diquat itself after direct application to soil. In large pot tests using several soil types, there was no significant degradation of diquat over a 2.5-year period. In the field, studies have shown no significant decrease in diquat residues in various soil types over 4.5 years. Photochemical degradation products of diquat formed on grass are not accumulated in soil when the sprayed sward is later incorporated into the soil (Valent U.S.A. Corporation, 1989).

In a field study, diquat applied at 0.25 to 0.5 lb a.i./acre did not degrade for three years after application to two plots in New York. The concentration of diquat in the upper 15-cm soil depth was 0.32 ppm in clay loam soils with no over crop at the time of application, and as low as 0.01 ppm in loam soil with a cover crop of potatoes at the time of application. Concentrations at the New York site were 0.01 to 0.03 ppm at 15 to 22.5-cm soil depths. Similar applications to loam soil at two sites in Idaho did not degrade for three years after application. Furthermore, the concentrations of diquat ion ranged from 0.01 to 0.13 ppm in the upper 35-cm soil depth (EPA, 1995). No residues were recovered from below 35-cm soil depth. Since no degradation of diquat was seen at long-term terrestrial sites, or in laboratory experiments with soil, it was not possible to determine the half-life of diquat on soils.

Recommended Mitigation:
Diquat cannot be sprayed within two meters of the shoreline except to control noxious weeds.

Sediment. Increases of diquat concentrations in sediment will often continue for up to a month after application to the water body. This continued increase in sediment concentrations of diquat is probably due to the initial adsorption of diquat by plants and subsequent release of diquat after the plants have died and sunk to the bottom of the water body. Although the concentration of diquat in sediment can be high and persistent, most soils appear to be able to adsorb diquat concentrations as high or higher than 250 ppm c.e. without release of diquat from the sediment (Hiltbran et al, 1972). Although diquat has a tendency to accumulate in some sediments over time, conservative estimates indicate that 10 to 50 applications would be necessary before the sorptive capacity of diquat would be overcome and diquat would be released back into the water column. However, more realistic estimates indicate that it would take hundreds of applications before the sorptive capacity of diquat was overcome and enough diquat could be released back into the water column to potentially cause damage to the biota (Dyson and Takacs, 2000; Shaw et al, 1995). In more than 30 years of diquat use to control aquatic weeds, there has never been a recorded release of bound diquat at concentrations that exceed the levels of aquatic organisms to tolerate it (Hiltibran et al, 1972 and Dyson and Takacs, 2000).

More than 90% of applied diquat can be adsorbed onto sediment under aerobic conditions in just a few days (EPA, 1995 and Simsiman and Chesters, 1976). Experiments showed an aquatic system with extensive growth of microbes can degrade diquat under aerobic conditions with a half-life of only 3.8 days. In one experiment 80% of the applied diquat was metabolized to volatiles (48% possibly CO2) and water-soluble metabolites (32%) within 22 days after application; and 19% of the diquat remained bound to the sediment. Other experiments in weed-free systems indicated that diquat does not readily degrade, more than 90% of the diquat adsorbs to the sediment within just a few days, and that diquat remains adsorbed and unchanged on the sediment for up to 180 days (Simisman and Chesters, 1976 and EPA, 1995). Additional work in the field indicates that diquat adsorbed to sediment is not biologically available to most microbes and that unchanged diquat may remain bound to the sediment for more than a year (Haven, 1969 and Beasley, 1966 in Hammer, 1994; Frank and Comes, 1967; Gilderhus, 1967 and Fujie, 1988).

Fujie (1988) found that residues of diquat were relatively immobile, remaining in the upper sediment profile, though minor detections of diquat were made at the lower depth. Fujie (1988) further found that multiple treatments at the maximum use rate did not increase the concentration typically found in sediment. No explanation of this observation was given. Other field sites include ponds in Colorado, Wisconsin and tidal basins (Nomini Creek, Virginia). Diquat was found at these sites to be fairly high in the sediment with concentrations typically reaching levels that are ten or more times higher than the initial concentration applied to water (0.35 to 3.0 ppm). The concentrations on sediment were observed to not decrease or to decrease only gradually after complete adsorption had occurred between 36 and 56 days after application for the duration of the experiment (160 to 356 days). As diquat is slowly released from the sediment over a long period of time it is likely to be rapidly dissipated by re-adsorption to sediment, degradation by microbes, or dissipation by dispersion or advection.

Recommended Mitigation:
Ecology will manage sediment monitoring internally.

Water

Surface Water. Numerous physical and chemical factors can affect the persistence and fate of diquat in the aquatic environment. Temperature influences the rate of both chemical and biological processes. Since diquat is not readily hydrolyzed at typical environmental temperatures, it appears unlikely that temperature will influence the degradation of diquat by hydrolysis, and generally the adsorption to montmorillonite and kaolinite clays is unaffected by temperatures between 10°C and 55°C. Although no work was done to test the hypothesis that temperature will affect the rate of microbial degradation, it seems reasonable to expect that within a very broad range of normal environmental temperatures (~5° C to ~45°C) the rate of microbial degradation will increase by two-fold for every 10°C increase in temperature. This temperature effect assumes that the microbial species degrading diquat remain viable throughout this temperature range. At temperature extremes (<5° C and >45° C) it can be expected that microbial degradation will slow up and eventually cease.

Water pH does not appear to play a significant role in the hydrolysis of diquat. Except at extremely high pH (>9) (Simsiman et al, 1976), the hydrolysis of diquat appears to be unaffected by pH.

Use of diquat in the treatment of dense weed areas can result in oxygen loss from decomposition of dead weeds. Deoxygenation can occur due to rapid use of oxygen during the decomposition of plants or algae and the loss of photosynthesis following herbicide treatment. Dissolved oxygen depletion is more rapid with diquat and copper treatments than 2,4-D or endothall treatments because death and decomposition is much faster.

Probably the most important physical process affecting diquat persistence in larger water bodies is transport of treated water away from the treated area and replacement with untreated water through lateral circulation or vertical movement of water. In this regard, the larger the lake, the more wind blowing across the lake surface, and the more water exchange through inlet and outlet streams or rivers, the more likely that diquat residues will be rapidly dispersed and diluted to below detection limits. In small lakes, detectable concentrations of diquat may be carried a significant distance down an outlet stream if the flow is sufficient and degradation is slow.

Recommended Mitigation:

1. A whole lake treatment can only be authorized for noxious plants and only under an approved Integrated Aquatic Vegetation Management Plan (IAVMP). Whole lake treatments must be done in thirds to avoid dissolved oxygen sags.
2. When treating noxious weeds, care should be taken to minimize impacts to native vegetation. Note: Algae blooms tend to occur after whole lake treatments.
3. The efficacy of diquat decreases in turbid water.
4. Applications should be made by subsurface injection whenever practicable to avoid drift.

Ground Water. The EPA RED (1995) has not reported any cases of ground water contamination from the proper or improper use of diquat. Because it is considered unlikely to contaminate ground water, Washington State did not monitor ground water for diquat between 1988 - 1995 (Ecology, 1996). Nevertheless, the most likely routes for contamination are spills during mixing of application solutions at wellheads, illegal dumping, surface water runoff from treated fields, and movement down through the soils from heavily treated agricultural land. With the exception of contamination by spills or illegal dumping, none these routes of ground water contamination is likely since diquat tenaciously adheres to soil and sediment and is unlikely to be released from soil except under the conditions of very heavy liming (Weber and Best, 1972 in Weber and Weed, 1974). With respect to ground water movement, the difference between terrestrial and aquatic weed control uses of diquat is that lakes provide, in essence, an isolated incubator in which diquat can be slowly released from the sediment and dissipated through slow microbial degradation or horizontal/vertical dispersion and advection by the slow flow of the water body (Ritter, 2000 and Waterborne, 1995).

Recommended Mitigation:
None beyond label restrictions.

Wetlands. The presence of diquat products at concentrations effective against weeds in wetland environments may adversely effect these environments. Dilution should mitigate the affects of diquat so that it does not affect aquatic plants or non-target animals in marsh, bank and estuarine areas. The presence of diquat in the lotic environment, due to outflow from a lake or pond, may cause the destruction of aquatic plants that are favorable to the production of habitat for sunfish, minnows and bass. The subsequent habitat, with a low level of aerial aquatic weed cover and a benthos consisting primarily of sand and gravel would be more appropriate to the production of salmonids.

The estuarine environment may be affected by the use of diquat**.** The more susceptible species of invertebrates are the pocket shrimp (*Mysidopsis bahia*) and the euryhaline amphipod (*Hyalella azteca*). Hyalella azteca is the most susceptible species tested and may be impacted adversely by diquat at concentrations typically found in the field.

There may be tendency for drift into other wet land environments or a flow of water into estuarine, palustrine, riparian, lentic or lotic environments. However, due to dilution effects as treated ponds, lakes, and canals normally flow into streams and rivers and ultimately into estuaries, it is not anticipated that the impact would be measurable.

Recommended Mitigation:

1. A mitigation plan shall be required for projects that impact wetlands.
2. Diquat cannot be sprayed within two meters of the shoreline except to control noxious weeds.

Plants

Selectivity. Most noxious plants are substantially reduced upon treatment with diquat. Nevertheless, it is clear that while native and desirable pondweed species do recover, some of the more difficult to control species like *Chara* spp., Duckweed (*Lemna* spp.), curly leaf pondweed, *Nymphaea* spp., *Nuphar* spp., and even water milfoil (*Myriophyllum* spp.) in the Northwest may come to dominate a treated water body (Johnson, 1962; Hulbert, 1987; Tatum and Blackburn, 1965; Daniel, 1972, and Shearer and Halter, 1980).

Diquat is not very selective when used at concentrations that will control water milfoil in the Northwest. However, diquat appears to be extremely effective in controlling *Elodea canadensis*, and many species of pondweed (*Potamogeton*), although some species like *P. richardsonii*, *P. robbinsii* and *P. nodosus* are difficult to control. Although Reward® LA is effective at controlling some species of algae; it appears to have a stimulatory affect on some species of green unicellular and green filamentous algae which can potentially lead to an algal bloom (Cooke, 1977).

Information from the label states that diquat can control the following plant species:

Submersed weeds	Bladderwort (*Utricularia* spp.) Naiad (*Najas* spp.) Coontail (*Ceratophyllum demersum*) Water milfoil (*Myriophyllum* spp.) Pondweed (*Potamogeton* spp. except *P. robbinsii*) Elodea (*Elodea* spp.) Hydrilla (*Hydrilla verticillata*)
Floating weeds	Waterhyacinth (*Eichhornia crassipes*) Salvinia (*Salvinia rotundifolia*) Waterlettuce (*Pistia stratiotes*) Pennywort (*Hydrocotyle umbellata*) Duckweed (*Lemna* spp.)
Marginal weeds	Cattail (*Typha* spp.)

Algae	*Pithophora* spp. *Spirogyra* spp.

Algae. Although efficacy is claimed on the label for only two genera of algae (*Spirogyra* spp. and *Pithophora* spp.), diquat is sufficiently toxic to be considered a high risk herbicide to most species of algae (Peterson et al, 1997). When applied at the historical concentration rate of 0.75 ppm c.e. in 2 feet of water, there is 100% inhibition of growth of all of the freshwater blue-green alga, green and diatom species tested (Peterson et al, 1997 and Peterson et al, 1994). An exception may be marine green algae and diatoms with EC50s that are quite high (6.48 to 4.3 ppm c.e. for marine green algae and 3.24 ppm c.e. for marine diatoms) (Walsh, 1972). Under the risk assessment scheme proposed by Peterson et al (1994), all of the species tested at ~ 0.75 ppm are at very high risk with more than 50% inhibition of growth and a risk quotient (EEC/EC50 >1.0) for diquat.

Recommended Mitigation:
Use as directed by the label.

Macrophytes. Diquat is toxic to indicator species of aquatic macrophytes at low concentrations. The representative species in the laboratory are *Lemna minor* and *Spirodela polyrhiza* and the toxicities (EC50s) of diquat are typically 0.001 to 0.01 ppm c.e. for *Lemna minor* and 0.00075 to 0.01 ppm c.e. for *Spirodela polyrhiyza.* Since use rates may be as high as 0.37 ppm c.e., these macrophytes would be controlled under typical field situations. Results from field and semi-field studies indicate that Eurasian water milfoil (*Myriophyllum spicatum*), coontail (*Ceratophyllum demersum*), American waterweed (*Elodea canadensis*), Sago pondweed (*Potamogeton pectinatus*), curly leaf pondweed (*P. crispus),* Richardson's pondweed (*P. richardsonii*), duckweed (*Lemna minor*), *Callitriche* spp., Hydrilla (*Hydrilla verticillata*), water lettuce, (*Pistia stratiotes*), water hyacinth (*Eichhornia crassipes*), *Salvinia molesta* and filamentous algae (*Mougeotia* spp. and *Zygnema* spp.) are controlled by diquat at concentrations between 0.25 and 0.5 ppm. All of these species are "controlled" by diquat, but not necessarily eradicated. However, the Reward® LA label does not recommend the use of diquat for the control of Richardson's pondweed and no efficacy is claimed for the control of *Callitriche* spp., *Mougeotia* and *Zygnema* spp. Eurasian water milfoil, curly leaf pondweed and duckweed are controlled by diquat, but use of diquat in the northwest appears to control Eurasian water milfoil for only about 2 months, curly leaf pondweed for only about 1.5 months and duckweed for only about 1 month (Johnson, 1962, Hulbert, 1987, and Water Investigation Branch, 1977 in Shearer and Halter, 1980).

Recommended Mitigation:
Use as directed by the label.

Endangered Plant Species. Reward® LA (liquid diquat) is normally applied at or below the water surface; thus accidental airborne "drift" exposure to upland vegetation during application would be minimal with the exception of emergent aquatic plant communities bordering the treated area. If any proposed "sensitive" plants or candidate species under review for possible inclusion in the state list of endangered or threatened species occurs along the banks of waterways to be treated with diquat products, the applicator should leave a protective buffer zone between the treated area and the species of concern (Ecology, 1989). Sensitive upland plant species could potentially be damaged if treated water was improperly used for irrigation or extensive flooding from irrigation canals treated with diquat for the control of terrestrial or emergent weeds growing on the ditch banks before significant herbicide dissipation had occurred. Use of treated water for irrigation is normally prohibited for three to five days after treatment with Reward® LA or until an acceptable analytical method shows the concentration of diquat has decreased below the level of concern (LOC). To protect endangered aquatic plants, some knowledge must be gained on the toxicity of diquat to these plants, or diquat must not be applied in areas that will adversely impact the habitat or population of these plants. In the case of threatened aquatic plants, the Endangered Species Act does not allow for the control of noxious weeds to take precedence over the protection of endangered species. However, if conditions indicate that removal of noxious weeds will improve habitat for threatened/endangered plant species, removal of the noxious species by chemical or other means should be considered. The permit for treatment of water bodies to control noxious or invasive plants may be denied or amended if Ecology believes that populations of endangered plants may be adversely impacted by treatments to control these weeds.

Endangered and threatened plant species found in riparian or aquatic sites in Washington State include: showy stickseed, Bradshaw's desert-parsley, Wenatchee mountains checker mallow, Kincaid's lupine, Spalding's catchfly, Ute Ladies' Tresses, Golden paintbrush, and Nelson checker mallow (terrestrial species); water howellia and marsh sandwort (aquatic species). For current listings see: http://www.wa.gov/dnr/htdocs/fr/nhp/refdesk and http://ecos.fws.gov/servlet/TESSWebpageUsaLists?state=WA

Recommended Mitigation:
Buffers and other protective measures must be employed for any known endangered plant species when necessary to protect them.

Animals

Freshwater Invertebrates. Several species of invertebrates are extremely susceptible to the laboratory effects of diquat. For example: diquat would be classified as very highly toxic (LC50 = <0.1 ppm) to the amphipod (*Hyalella azteca*) (LC50 = 0.048 ppm c.e.), highly toxic to the pocket shrimp (*Mysidopsis bahia*), *Daphnia pulex* and apple snail (*Pomacea pludosa*) (LC50 = 0.42, 0.16 and 0.34 ppm, respectively). However, for most species of invertebrates diquat is classified as much less toxic; e.g. diquat is classified as moderately toxic (LC50 = >1.0 to 10 ppm) to practically nontoxic (LC50 = 100 ppm) for mayflies (*Callibaetis* spp.), oysters (*Crassostrea virginica*), *Daphnia magna, Diapotomus* spp., *Eucyclops* spp., various odonates, caddis fly *(Limnephilus* spp.), various species of marine shrimp and bloodworms (*chironomidae*) (LC50 = 16, 55 to 141, ~1.0, ~5, 25. >100, 33, >1.0 to 8.5 and >100 ppm c.e.). Most other species of free swimming and benthic invertebrates show similar affects in laboratory testing (Appendix A, Section 4, page 63). Although diquat has a tendency to accumulate in some sediments over time, conservative estimates indicate that 10 to 50 applications would be necessary before the sorptive capacity of diquat would be overcome and diquat would be released back into the water column. However, more realistic estimates indicate that it would take hundreds of applications before the sorptive capacity of diquat was overcome and enough diquat could be released back into the water column to potentially cause damage to the biota (Dyson and Takacs, 2000; Shaw et al, 1995).

Recommended Mitigation:
1. Diquat cannot be sprayed within two meters of the shoreline except to control noxious weeds.
2. Apply diquat at lowest effective concentration as specified on the label.

Avian. Information on effects of diquat dibromide on birds indicates that it ranges from nontoxic to moderately toxic, depending on the bird type tested (EPA 1986). The acute oral LD50 for mallard ducks ranges from 60.6 ppm to 31 ppm (expressed as cation equivalents). These data indicate that diquat is moderately toxic to the mallard duck when orally dosed. The lowest LC50 for diquat (expressed as cation equivalents) is 264 ppm for Japanese quail and the highest LC50 for birds is listed as 575 ppm for bobwhite quail. These data indicate that diquat is moderately toxic to birds when consumed in the diet. The LC50 for mallards was >5,000 ppm and for pheasants was 3,600 - 3,900 ppm (Pimental 1971). In a study found by EPA to be scientifically sound but not meeting EPA's guidelines for an avian reproduction study for the registration standard, reproductive testing of bobwhite quail revealed that "at the 5 ppm cation [diquat] treatment level, a statistically significant difference ($p < .01$) was observed in the body weights of both the hatchlings and the 14-day old survivors." The study author concluded "while statistically significant, the actual effect was very slight, and it is not considered to be biologically meaningful."

Recommended Mitigation:
Diquat cannot be sprayed within two meters of the shoreline except to control noxious weeds.

Wetland Species. Ideally, additional acute and chronic work needs to be done on fully aquatic and water associated animal species. These species include aquatic reptiles (turtles), amphibians (salamanders, toads, and frogs), Lepidoptera and other insects associated with wetland communities or used as biocontrol agents on aquatic plants. Additional work with amphibians is important because the endangered leopard frog and African clawed toad (*Xenopus laevis*) have been shown to be acutely sensitive to diquat. The chronic MATCs for these species is 1.7 and 0.64 ppm c.e., respectively and diquat at levels 1 to 2 ppm was highly embryotoxic to the clawed frog (Appendix A, Section 4, page 104). The African clawed toad is not native to Washington, but may serve as an indicator species of amphibians. However, WDFW suggests that Woodhouse's toad and the northern leopard frog are more relevant to Washington State.

Recommended Mitigation:
1. Diquat cannot be sprayed within two meters of the shoreline except to control noxious weeds.
2. A mitigation plan shall be required for projects that impact wetlands.
3. Apply diquat at lowest effective concentration as specified on the label.

Fish. Exposure of Coho salmon to diquat in the laboratory showed that diquat may adversely impact the parr to smolt metamorphosis at concentrations as low as 5.0 to 20 ppm. Smolting salmon exposed to this concentration of diquat experienced 15% to 87.5% mortality when subsequently exposed to seawater. Additional experiments with concentrations of up to 3.0 ppm diquat did not produce mortality when Coho salmon were exposed to diquat. However, exposure to concentrations as low as 0.5 ppm interfered with the ability of Coho salmon to migrate downstream. Concentrations of 3.0 ppm diquat produced histopathological effects on eyes, kidney, gills, and liver (Lorz et al, 1979). However, similar experiments with Chinook salmon at concentrations ranging from 0.125 to 0.5 ppm c.e. produced no mortality or osmoregulatory effects in a subsequent seawater challenge (Merill, 1997). Other anadromous fish species like steelhead, sea-run cutthroat trout or American eel have not been tested for their ability to osmoregulate or migrate appropriately. Since there is some evidence that diquat may affect seawater survivability and migration at concentrations that may be encountered in the environment, this is worth further investigation. It also indicates the permits should be written so that breeding and smolting anadromous species are not exposed to diquat (Appendix A, Section 4, pp. 64-65, and 79).

Behavioral effects have been observed on exposure to diquat. Rainbow trout do not exhibit active avoidance behavior at concentrations of diquat up to 10 ppm c.e. (Folmar, 1977). However, passive avoidance behavior, a tendency to drift with the current, has been observed in rainbow trout exposed to concentrations of diquat as low as 0.5 ppm c.e.(Dodson and Mayfield, 1979). Similar effects were observed in fathead minnow at concentration of diquat as low as 9.2 ppm c.e. (de Peyster and Long, 1993) An active avoidance response to diquat was seen in goldfish at concentrations as low as 1.1 ppm diquat (Berry, 1984). In the field, carp and suckers would avoid diquat at very high field use rates (26.7 ppm). However, rainbow trout did not display any reaction to the diquat during field exposure (Hesser et al, 1972). Passive avoidance may have been the result of respiratory distress (coughing). Respiratory distress has been displayed in yellow perch exposed to concentrations of 1 to 5 ppm diquat (Bimber et al, 1976). This may be environmentally relevant since even at concentrations of 1.0 ppm, respiratory stress is demonstrated within 6 hours of exposure.

Fish species like largemouth bass, sunfish and others are not adversely affected by typical field concentrations of diquat. There was no adverse effect on numbers (experimental largemouth bass catch) and no adverse effect on mean total length, condition, and movement within the treatment area. Furthermore, fingerling bluegill sunfish grew at the same rate in control and treatment ponds while the average increase in the size (length and weight) of adults was much reduced in the treated ponds. However, the total harvest weight did not differ between treated and untreated ponds. Fall spawning of bluegills from treated ponds was successful with 100 adults/acre producing approximately 100,000 fry per acre.

Diquat has been used to treat disease in fish at hatcheries, and for the species tested, diquat did not affect the breeding rate of fish or cause mortality in juveniles (Gilderhus 1967). Rates of 1 ppm diquat applied up to 3 times and 3 ppm applied once or twice, with 8-week intervals between applications, had no adverse effect on hatching and growth rates of bluegills in seven different pools. Channel catfish fry were not affected at 10 ppm diquat and bluegill fry were not affected at 4 ppm diquat. Largemouth black bass fry were more sensitive and were affected at levels greater than 1.0 ppm at 22.5°C and at 0.5 ppm at 26.0°C (Jones 1965).

Recommended Mitigation:

1. Permits will be written so that anadromous species are not exposed to Diquat. Treatments are subject to WDFW timing table.
2. Apply diquat at lowest effective concentration as specified on the label.
3. Except for noxious weed control, contiguous areas covering a minimum of 25 to 40 percent of the vegetation shall be left intact in the littoral area. When treating large areas, random strips or patches of aquatic vegetation must be left untreated for fish habitat use. At least 25 to 40 percent of the submerged vegetative cover must be retained for optimum cover and forage for fish and wildlife.

Mammals. Acute oral data is available for more than one mammalian species for diquat dibromide and LD50 values range from 120 mg/kg in rats to 233 mg/kg in mice (See Table 26, Appendix A, Sect. 4, p. 184). This data indicates that diquat is moderately toxic. However, the reported LD50 for cows is listed as 30 to 56 mg/kg, which indicates that diquat is highly toxic to cows. There are two common routes of exposure for livestock and terrestrial wildlife to aquatic applications of diquat products. The two routes are exposure through drinking water treated with products containing diquat or eating aquatic plants, plants along a shoreline that have been treated accidentally by overspray, and by eating fish or other aquatic organisms from the treatment site.

Recommended Mitigation:

The Reward® label restricts the use of treated water for watering livestock for one day following treatment. Many studies have been run on diquat products to ensure their safety to wildlife and the label directions and warnings reflect the results of these studies. Therefore, if the chemicals are applied according to the label the effect on terrestrial wildlife should be minimal.

Threatened and Endangered Species. Treatment with herbicides has the potential to affect submersed and emergent plant species federally listed as rare, threatened, or endangered. These species may be aquatic or may occur along the banks of waterways. Animals such as the spotted frog, a state and federal candidate for listing as endangered, threatened, or sensitive may be affected. Sensitive, endangered and threatened species of aquatic animals that may need protection through mediation include Coho salmon, chum salmon (summer chum), Chinook salmon, sockeye salmon, bull trout, steelhead trout, cutthroat trout, coastal cutthroat trout, Olympic mud minnow, mountain sucker, lake chub, leopard dace, Umatilla dace, and river lamprey. Other species which may need protection within Puget Sound, the San Juan Islands, and the Strait of Juan de Fuca east of the Sekiu River are Cherry Point herring, Discovery Bay herring, and South Pacific cod.

Recommended Mitigation:
No treatments are allowed where state or federal ESA listed species may be present.

Water, Land and Shoreline Use

Public Water Supplies and Swimming. Diquat could impact drinking water directly from a treated water body. Risk assessments were significantly exceeded in situations where the source of drinking water involved diquat treated water during the 24 to 36 hours following aquatic application. Although the calculated diquat doses were elevated they remained 13 - 76 times below the systemic animal chronic toxicology NOAEL. In studies conducted in Washington State, (Serdar, 1997) found that the concentration of diquat in water exceeded the maximum contaminant level goal (0.02 ppm c.e.) for the first 12 days after treatment.

Persons swimming in water treated with the highest use-rate of diquat (0.37 ppm) are not expected to experience significant adverse health effects. Based on the results of the toxicology studies, the product use-rates, and the diquat binding properties, systemic toxicity from swimming is very unlikely. The risk assessment shows that a ten-year old child would need to drink massive amounts of water (~3.5 gallons), containing 0.37 ppm diquat while swimming for three hours to approach the No Observable Adverse Effect Level (NOAEL) dose of 220 mg/kg/d. The only swimming scenario that falls below the target Margin of Safety (MOS) involved a six-year-old child swimming for three hours in water assumed to contain the maximum use rate of 0.37 ppm. The target MOS (margin of safety) is 100 times less than the chronic NOAEL. In this scenario, the estimated dose absorbed by the child would still be 87 times less than the chronic NOAEL.

Prolonged eye contact with water containing 0.37 ppm diquat may result in the swimmer experiencing some possible chemical-associated temporary minor eye irritation or conjunctivitis. Any redness is expected to remit within a day. As diquat concentration decreases rapidly in water over 24 hours, so would the potential for eye irritation.

Recommended Mitigation:

1. In addition to a two meter buffer along the shoreline and buffers necessary for protection of endangered plant species, the following buffers apply unless otherwise mitigated through an approved Integrated Aquatic Vegetation Management Plan:
   - <u>Flowing water</u> (e.g., rivers, streams, canals): Do not apply within 1600 feet upstream of operating potable water intake sites and outlets.
   - <u>Standing water</u> (e.g., lakes, reservoirs): Do not apply within 1400 feet for rates at 2 gals/acre, or within 700 feet for rates at 1 gal/acre, or within 350 feet for rates equal to or less than 0.5 gal/acre of potable water intake sites and outlets. For rates between 1 and 2 gal/acre, distance may be adjusted (e.g. 1 ¾ = 1225, 1 ½ = 1050, 1 ¼ = 875').
2. The label restricts livestock from accessing water that has been treated with diquat for 1 day after treatment.
3. A 24 hour advisory must be posted for swimmers due to the potential for eye irritation from exposure to treated water.

Release of Toxic Materials – Inhalation. Ethylene dibromide (EDB) is used in the manufacture of diquat and is found in very small quantities as an impurity. The certified maximum EDB level permitted in the formulated products is 10 ppm. EPA has concluded that the presence of EDB as an impurity does not pose significant risk to human health (EPA, 1995). However, if diquat concentrate is spilled during formulating operations and allowed to stand, it can dry to a highly irritating dust. Symptoms of inhalation overexposure to spray mist or dust may include headache, nosebleed, sore throat, and coughing.

Recommended Mitigation:

1. Spills of Diquat will be cleaned up immediately. The spill should be covered with a generous amount of absorbent (clay or loam soil), and the absorbent mixed with a broom then swept. Finally, if it is on an impervious surface, the spill area should be scrubbed with detergent and water.
2. The pouring of Diquat concentrate into water directly from the container is prohibited.

Fish consumption. The EPA labels for diquat have no fishing restrictions.

Agriculture. A concern with the use of diquat is damage by drift to plants and crops. However, adequate label warnings are given which, if followed, would prevent drift from occurring.

Recommended Mitigation:
The EPA label restricts use of diquat treated water for irrigation of food crops for 5 days after application. Phytotoxic damage to most crops irrigated with water containing 0.5 ppm diquat is unlikely; nevertheless, residues of the chemical could occur, particularly in leafy vegetables subjected to several prolonged irrigations (Davis et al. 1972 in Valent U.S.A. Corporation 1989).

Data Gaps and Considerations

- The importance of the role of sediment in removing diquat from the environment should be investigated along with the effects of diquat in sediment on benthic organisms. Levels of diquat in the sediment are particularly important since there is a potential for diquat to accumulate to very high levels. However, modeling work shows that typical diquat levels will not exceed 25 ppm c.e. in the field and actual field monitoring studies have shown that diquat may accumulate on sediment up to concentrations as high as 37 ppm c.e. when it is applied at typical application rates (Dyson and Takacs, 2000 and Frank and Comes, 1967). Diquat in sediment at concentrations below ~ 250 ppm is believed to be irreversibly bound and biologically unavailable. Therefore, diquat that is bound to the sediment is unlikely to be toxic to either animals or plants (Wilson, 1967 Birmingham and Colman, 1983; Coats et al, 1966 and Daniel, 1972).

- The effects of post-treatment plantings of native aquatic plants need to be investigated to determine if this is a practical approach to re-vegetation after the elimination of water milfoil. However, wheat, duckweed and Eurasian water milfoil that have been planted in soil/sediment continue to grow on soils that have been treated with 170 ppm c.e. to 5,000 ppm c.e. diquat. Growth was somewhat inhibited with more sensitive plants and soils with relatively low adsorptive capacity. Further investigations with varying treatment rates and conditions should be conducted to determine which rates and conditions cause the greatest destruction of water milfoil and the least damage to native aquatic plants.

- The toxicity of diquat to sensitive fish and invertebrate species is well enough understood to adequately manage the risk associated with aquatic weed control. However, further investigations need to be conducted to determine what levels of diquat are safe to sensitive, threatened and endangered species such as salmon, sea-run trout and the western pond turtle. Additional studies emphasizing species indigenous to the Northwest such as the spotted frog, northern leopard frog and Woodhouse toad should be conducted so that risk due to exposure can be managed more effectively. This is of particular concern for benthic organisms since regulators, registrants, the applicator community and the general public has recently expressed great concern over this issue.

- Additional acute and chronic work needs to be done on fully aquatic and water associated animal species. These species include aquatic reptiles (turtles), amphibians (salamanders, toads, and frogs), Lepidoptera and other insects associated with wetland communities or used as biocontrol agents on aquatic plants. Additional work with amphibians will be important because the endangered leopard frog and African clawed toad (*Xenopus laevis*) have been shown to be acutely sensitive to diquat. The chronic MATCs for these species is 1.7 and 0.64 ppm c.e., respectively and diquat at levels 1 to 2 ppm was highly embryotoxic to the clawed frog.

- A timing table from the Washington Sate Department of Fish and Wildlife (WDFW) is a critical mitigation tool expected to protect anadromous species but is not yet completed. WDFW anticipates that the timing table will be ready before the 2003 growing season.

- Syngenta is submitting a revised Federal label for Reward® that should be approved by EPA in February 2003. The proposed label will be based on concentrations in water (ppm) rather than rate (lbs./acre). The new label will state that the applicator should not exceed 0.37 ppm during treatment. The applicator can use more Reward® in proportion to average water depth. Under the current label the applicator can apply Reward® at a rate where concentrations can reach beyond 0.75 ppm. There is a table below which lists the average water depths and the amount of diquat application. Note: the table is expressed in terms of "product" (Reward®) in gallons to achieve the two rates used for weed control (0.37 and 0.19 ppm).

	1ft	2ft	3ft	4ft	5ft	6ft	7ft	8ft	9ft	10ft
0.19 ppm	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5
0.37 ppm	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5

4. Mitigation Summary for Diquat

All label restrictions and conditions apply. Spill response conditions found in the general conditions of the water quality permit must be applied in the event of a spill.

Conditions of Treatment	**Mitigation Recommendation**
Repeat applications	Diquat cannot be applied to the same area of a waterbody more than twice per growing season. Repeat treatments should be minimized by follow-up Integrated Pest Management (IPM) methods to herbicide applications. Except for early infestation of noxious weeds, the second treatment and treatments thereafter are only allowed under an approved Integrated Aquatic Vegetation Management Plan (IAVMP).
Drift onto adjacent shorelines	Except to control noxious weeds, diquat cannot be sprayed within two meters of the shoreline. Applications should be made by subsurface injection whenever practicable to avoid drift.
Eutrophic conditions and turbidity	The efficacy of diquat decreases in turbid water.
Whole lake treatments (>50% of the lake) or when treatment is made to small lakes with outlets, or for spot treatment applications near outlets.	A whole lake treatment can only be authorized for noxious plants and only under an approved IAVMP. Whole lake treatments must be done in thirds to avoid dissolved oxygen sags. When treating noxious weeds, care should be taken to minimize impacts to native vegetation. Note: Algae blooms tend to occur after whole lake treatments.
Wetlands	A mitigation plan shall be required for projects that impact wetlands.
Sensitive biota, including amphibians, birds and	Apply diquat at lowest effective concentration as specified on the label.

waterfowl	
Anadromous fish	Permits will be written so that anadromous species are not exposed to Diquat. Treatments are subject to WDFW timing table.
ESA listed species in area	No treatments are allowed where state or federal ESA listed species may be present
WDFW requirements for habitat conservation	Except for noxious weed control, contiguous areas covering a minimum of 25 to 40 percent of the vegetation shall be left intact in the littoral area. When treating large areas, random strips or patches of aquatic vegetation must be left untreated for fish habitat use. At least 25 to 40 percent of the submerged vegetative cover must be retained for optimum cover and forage for fish and wildlife.
Native plants	Use as directed by the label.
"Sensitive" plants or candidate species under review for possible inclusion in the state list of endangered or threatened species occurring along the banks of waterways to be treated.	Buffers and other protective measures must be employed for any known endangered plant species when necessary to protect them.
Spills	Spills of diquat should be cleaned up immediately. The spill should be covered with a generous amount of absorbent (clay or loam soil), and the absorbent mixed with a broom then swept. Finally, if it is on an impervious surface, the spill area should be scrubbed with detergent and water.
Algae	Use as directed by the label.
Domestic uses, including irrigation, livestock watering and swimming	The label restricts livestock watering for 1 day, and irrigation of food crops for 5 days post-treatment. A 24 hour advisory must be posted for swimmers due to the potential for eye irritation from exposure to treated water.
Drinking water	Label restricts drinking water use for 3 days post-treatment. In addition to a two meter buffer along the shoreline and buffers necessary for protection of endangered plant species, the following buffers apply unless otherwise mitigated through an approved Integrated Aquatic Vegetation Management Plan: Flowing water (e.g., rivers, streams, canals): Do not apply within 1600 feet upstream of operating potable water intake sites and outlets. Standing water (e.g., lakes, reservoirs): Do not apply within 1400 feet for rates at 2 gals/acre, or within 700 feet for rates at 1 gal/acre, or within 350 feet for rates equal to or less than 0.5 gal/acre of potable water intake sites and outlets. For rates between 1 and 2 gal/acre, distance may be adjusted (e.g. 1 ¾ = 1225, 1 ½ = 1050, 1 ¼ = 875').
Application methods	No aerial applications permitted because impacts have not been evaluated. The pouring of Diquat concentrate into water directly from the container is prohibited.
Fish consumption	Human health should not be adversely impacted from exposure via ingestion of fish.
Persistence in soil	Treatment with Diquat is restricted to submersed plants, floating plants and filamentous algae. A two meter buffer from the shoreline must be used except for noxious weed control efforts due to non-target exposure and persistence in soil. Diquat is not allowed for use on emergents in drainage ditches, wetlands or riparian areas due to its long-term persistence in soil unless otherwise authorized.
Persistence in sediment	Ecology will manage sediment monitoring internally.

References

1. Bowmer, K.H. 1982. Adsorption characteristics of seston in irrigation water: Implications for the use of aquatic herbicides. Australian Journal of Marine and Freshwater Research, 33(3):443-458.

2. Coats, G.E., H.H. Funderburk, Jr., J.M. Lawrence, and D.E. Davis. 1966. Factors affecting persistence and inactivation of diquat and paraquat. Weed Research, 6:58-66.

3. Cook, A.S. 1977. Effects of Field Applications of Herbicides Diquat and Dichlobenil on Amphibians. Environmental Pollution 12: 43-50.

4. Crafts, A. S. 1975. Modern Weed Control. University of California Press, Berkeley, CA.

5. Daniel, T.C. 1972. Evaluation of Diquat and Endothall for Control of Water Milfoil (Myriophyllum exalbescens) and the Effect of Weedkill on the Nitrogen and Phosphorous Status of a Water Body. Doctoral Thesis. University of Wisconsin.

6. Dodson, J.J., and C.I.Mayfield. 1979. Modifications of the Rheotropic Response of Rainbow Trout (*Salmo gairdneri*) by Sub-lethal Doses of the Aquatic Herbicides Diquat and Simazine. Environmental Pollution 18(2): 147-157.

7. Dyson, J.S. and M.G.Takacs. 2000. Diquat: Occurrence and Safety in Aquatic Sediments. Zeneca Agrochemicals. ID No. TMJ4467B.

8. Ecology. 1989. Draft Environmental Impact Statement Supplement. State of Washington Aquatic Plant Management Program. U.S. Army Corps of Engineers, Seattle District.

9. Ecology. 1996. Washington State Pesticide Monitoring Program. Pesticides in Washington State's Ground Water - A Summary Report, 1988-1995. Pesticides in Ground Water report No. 9. Publication No. 96-303.

10. Ecology and Environment, Inc. 1991. A Review and Evaluation of Factors Affecting the Safety of the Use of Diquat Dibromide in Aquatic Weed Control Applications. Ecology and Environment, Inc. and Washington State Department of Ecology Contract No. C0089007. Seattle, WA. July 1991.

11. Environmental Protection Agency. 1986. Guidance for re-registration of pesticide products containing as the active ingredient diquat dibromide (032201). Case number 0288. CAS 85-00-7. Office of Pesticide Programs. Washington, D.C.

12. EPA. July 2002. National Primary Drinking Water Regulations. 816-F-02-013.

13. EPA. 1995. Re-registration Eligibility Decision (RED): Diquat Dibromide. Publication No. EPA 738-R-95-016. United States Environmental Protection Agency. Washington, D.C.

14. Fujie, G.H., 1988. Aquatic Field Dissipation Studies with Diquat Herbicide. Chevron Chemical Company. ID No, R10/1642AQDISS. MRID 40917403.

15. Gilderhus, P.A. 1967. Effects of diquat on bluegills and their food organisms. Progressive Fish Culturist, 29:67-74.

16. Gosselin, R. E. et al. 1984. Clinical toxicology of commercial products. Fifth edition. Williams and Wilkins, Baltimore, MD.

17. Hammer, M.J. 1994. Diquat: Fate and Effects in the Aquatic Environment. Zeneca Agrochemicals. ID No. TMJ3204B. MRID 43383202.

18. Hartley, D. and H. Kidd. 1983. The Agrochemicals Handbook. Royal Society of Chemistry, Nottingham, England.

19. Hesser, E.F., R.W. Lowry, and E.O. Gangstad. 1972. Aquatic Plant Problems in the Walla Walla District. Hyacinth Control Journal 11: 9-13.

20. Hiltibran, R.C., D.L., Underwood and J.S. Fickle. 1972. Fate of Diquat in the Aquatic Environment. University of Illinois, Water Resources Center. Water Research Report No. 52. Final Report –

Project No. A-035-ILL.

21. Hudson, R. H. 1984. Handbook of toxicity of pesticides to wildlife. Second edition. United States Department of the Interior. Fish and Wildlife Service. Resource Publication 153. US Printing Office. Washington, D.C.

22. Hulbert, J.C. 1987. "Evaluation of Diquat for Vegetative Vigor and Growth". Unpublished study prepared by Chevron Chemical Co. Richmond, CA. Laboratory Project Identification Numbers 1184-20, 1185-03, 1184-34, 550-04, 1692-22, 1693-22, 1692-38, 1693-12, 1754-43.

23. Hunter, R., L. Faulkner, T. Kaiserski, and D. Antonsen. 1984. QSAR System. Center for Data Systems and Analysis, Montana State University. Bozeman, Mt.

24. Johnson, L.D. 1962. Evaluation of Diquat for Field Tests of Herbicides. Chevron Chemical Company. ID No. 87022C & 87025-C. MRID 40165103.

25. Jones, R.O. 1961 & 1965. Tolerance of the Fry of Common Warm-Water Fishes to Some Chemicals Employed in Fish Culture. Proceeding of the 15^{th} Annual Conference South Eastern Association of Game and Fish Commissioners: 16: 436-445.

26. Knight, B.A., and T.E. Tomlinson. 1967. The interaction of paraquat (I:1'-dimethyl 4:4'-dipyridylium dichloride) with mineral soils. J. Soil Science, 18:233-243. Cited in Bowmer, 1982.

27. Lorz, H.W., S.W. Glen, R.H. Williams, C.M. Kunkel, A.Logan, L.A. Norris and B.R. Loper. 1979. Effects of Selected Herbicides on Smolting of Coho Salmon. United States Environmental Protection Agency. EPA-600/3-79-071.

28. Merrill, Nathaniel. 1997. A Seawater Challenge Test with Chinook Salmon Smolts (*Oncorhynchus tshawytscha*) Following an Acute Exposure to the Aquatic Herbicide Reward® (Diquat dibromide). Report prepared by Parametrix, Inc., Kirkland, WA for Zeneca AG Products, Richmond, CA. July 1997.

29. Peterson, H.G., C. Boutin, K.E. Freemark and P.A. Martin. 1994. Aquatic Phytotoxicity of 23 Pesticides Applied at Expected Environmental Concentration. Aquatic Toxicology 28: 275-292.

30. Peterson, H.G., C. Boutin, K.E. Freemark and P.A. Martin. 1997. Toxicity of Hexazianone, and Diquat to Green Algae, Diatoms, Cyanobacteria and Duckweed. Aquatic Toxicology 39: 111-134.

31. Pimentel, D. 1971. Ecological effects of pesticides on non-target species. EPA Report No. EPA-540/9-71-006, Washington, D.C. 225 pp.

32. PTI Environmental Services.1991. Toxicity Assessment of Diquat and Comparison with Endothall. Issue Paper for PTI and Washington State Department of Ecology Contract C1640101. Bellevue, WA.

33. Purdue University. 2000. Herbicide Mode-Of-Action Summary. Cooperative Extension Service, West Lafayette, IN. www.agcom.purdue.edu/AgCom/Pubs/WS/WS-23.htm. Accessed June 26, 2000.

34. Reward® Landscape and Aquatic Herbicide Label. 2000. Specimen Label from Zeneca, C&P Press.

35. Ritter, A.M., J.L. Shaw, W.M. Williams, and K.Z. Travis. 2000. Characterizing Aquatic Ecological Risks from Pesticide Using A Diquat Dibromide Case Study. I. Probablistic Exposure Estimates. Environmental Toxicology and Chemistry 19(3):749-759

36. Rodgers, J.H., Jr., A. Dunn, and R. Robison. 1992. Guntersville Reservoir Herbicide Monitoring Survey, 1990. Mississippi Univ., University. Dept. of Biology. Report No. TVA/WR-92/20, October 1992. 170 pp. NTIS Accession Number DE930 404 23.

37. Serdar, Dave. 1997. Persistence and drift of the aquatic herbicide diquat following application at Steilacoom and Gravelly Lakes. Publication No. 97-301. Environmental Investigations and Laboratory Services Program, Washington State Department of Ecology, Olympia, Washington.

38. Shaw, J.L., K.Z. Travis, K.Z and A.M. Wadley. 1995. Zeneca 90-Day Response to Diquat Re-registration Eligibility Decision (RED): Environmental Fate and Ecological Risk to Aquatic Organisms and Non-Target Plants. Zeneca Agricultural Sciences. ID no. JLS 11112. MRID 43886001.

39. Shaw, Jennifer L. 2002. Personal communication. Syngenta, Greensboro, North Carolina.

40. Shearer and Halter, M. 1980. Literature Reviews of Four Selected Herbicides: 2,4-D, Dichlobenil, Diquat & Diquat. METRO.

41. Simsiman, G.V., and G. Chesters. 1976. Persistence of diquat in the aquatic environment. Water Research. 10:105-112.

42. Singh, P. and P.E. Williams. 1997. Diquat: Effects of Treatment Area on Aquatic Dissipation of Diquat and Determination of Upstream Setback Distances. Addendum to 'Estimated Environmental Concentrations Resulting from Aquatic Uses of Diquat. Zeneca Agrochemicals. MRID 44492901.

43. Smith, A.E., and J. Grove. 1969. Photochemical degradation of diquat in dilute aqueous solution and on silica gel. Journal of Agricultural and Food Chemistry, 17:609-613.

44. Tatum, W.M. and R.D. Blackburn. 1962. Preliminary Study of the Effects of Diquat on the Natural Bottom Fauna and Plankton in two Subtropical Ponds. Proceedings of the Sixteenth Annual Conference Southeastern Association of Game and Fish Commissioners (October 14-17, 1962) 16: 247-257.

45. Valent U.S.A. Corporation. 1989. Correspondence to Washington Department of Ecology.

46. Walsh, G.E. 1972. Effects of Herbicides on Photosynthesis and Growth of Unicellular Algae. Hyacinth Journal 10: 45-48.

47. Westerdahl, H., and K. Getsinger. 1988. Aquatic Plant Identification and Herbicide Use Guide. Volume 1: Aquatic Herbicides and Application Equipment. Technical Report A-88-9. US Army Engineer Waterways Experiment Station, Vicksburg, MS. 146 pp.

48. Waterborne Environmental, Inc. 1995. Estimated concentrations resulting from aquatic uses of diquat. Unpublished report by Waterborne Environmental, Inc., Leesburg, Virginia for Zeneca Limited. 136 pages.

49. Weber, J.B., S.B. Weed, and J.A. Best. 1969. Displacement of diquat from clay and its phytotoxicity. Journal of Agricultural and Food Chemistry, 17:1075-1076.

50. Westerdahl, Howard E., and K.D. Getsinger., eds. 1988. "Aquatic Plant Identification and Herbicide Use Guide; Volume II: Aquatic Plants and Susceptibility to Herbicides," Technical Report A-88-9, US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

51. Worthing, C.R. ed. 1991. "The Pesticide Manual". British Crop Protection Council. Old, Woking, Surrey, UK.

52. Wilson, D.C. 1967. The Effects of the Herbicide Diquat and Dichlobenil on Pond Water Invertebrates. M.S. Thesis for Fisheries at Oregon State University.

Section VIII. Responsiveness Summary

Final Supplemental Environmental Impact Statement For Diquat Dibromide

Washington State Department of Ecology
Water Quality Program
November 2002

A. Introduction

The proposed supplemental action evaluates the aquatic herbicide diquat dibromide not permitted by Washington State Department of Ecology (Ecology) since 1980. The recommended alternative is an integrated aquatic plant management approach using the most appropriate mix of vegetation control methods that may include biological, manual/mechanical, and chemical methods. Other alternatives analyzed in the Supplemental Environmental Impact Statement (SEIS) include chemical use only, mechanical use only, biological use only, and no action, which is the continuation of current policy.

Ecology encouraged the public to comment on the Draft SEIS for Diquat. A comment period was open from October 1, 2002 to November 6, 2002. A Focus Sheet describing the Draft SEIS and announcing a public review period and two Open House Forums scheduled in Eastern and Western Washington was mailed out to approximately 300 people on September 25th, 2002. An Ecology news release issued statewide on September 25th, 2002 also announced the public review period and the two scheduled Open House Forums. A Fact Sheet describing the proposed action and the public review period was mailed with the Draft SEIS September 27th 2002 to approximately 300 people, including 50 state libraries.

Ecology hosted Open House Forums in Bellevue on November 5th and in Spokane on November 6th. Approximately 12 members of the public attended the Open House Forums. Comments were received at the Open House forums as well as through regular and electronic mail during the comment period.

The public comments generally focused on the following issues:

- Support for diquat,
- Concerns of persistence in sediment, soil and the water column,
- Concerns regarding swimming in treated water,
- Potentially harmful effects on fish, invertebrates, amphibians and native plants,
- Lack of sufficient information, and
- Product necessity.

These concerns were reviewed by Ecology and responses are stated below.

B. List of Persons Providing Comments

1. Diana L. Nihem, Washington State Citizen
2. Kurt Madison, Washington State Horticulturalist and Estate Manager
3. Erika Schreder, Washington Toxics Coalition
4. Dan Wickham, Syngenta Professional Products
5. Bob Parker, Washington State University at Prosser
6. Doug Dorling, State Licensed Pesticide Applicator

C. Comments and Responses

Six people submitted fourteen comments on the Draft SEIS for diquat. Comments received have been summarized by category. Comment originators are referenced by their list number at the end of each comment. Responses to the comments are given directly after each comment. Changes to the Draft SEIS are summarized after the Comments and Responses section.

1. General Comments

1. I would like to comment in support of the permit and say that Syngenta is prepared to assist in determination of some of the aspects with which Ecology is concerned. Diquat has been fully evaluated with respect to its safety to applicators, human health, and the environment and was recently re-registered by the United States Environmental Protection Agency. Reward®, which is a trade name for diquat, must be applied to aquatic environment following specific label use directions. Label uses are fully supported by exposure, toxicity, and risk assessments that indicate no unreasonable adverse effects to human health or the environment. Diquat rapidly dissipates in water due to its high water solubility and highly absorptive characteristics. Potential exposure is further reduced by microbial degradation in plants and in water and by the action of sunlight. Specifically, rapid dissipation in water systems, loss of biological activity on contact with sediments, lack of movement from vicinity of application once absorbed, extensive environmental safety database, earth comprehensive exposure assessments covering all relevant waterbodies in the U.S. show no reason for concern and finally over all the use of Reward® or diquat results in substantial benefits to aquatic ecosystems that are adversely effected by invasive weeds. (4)

Response: Comment noted.

2. Please do not allow any use of this agent in Washington State. I am strongly against legalizing and licensing the use of diquat dibromide to control aquatic pests. (1)

Response: Comment noted.

3. Thank you. I'm Bob Parker, Washington State University at Prosser. The address is 24106 North Bunn Road, Prosser, Washington 99350. I'm in support of this, the use of diquat in the state of Washington. It's more effective early in the season, then the alternative which is Aquathol®. The temperature for Aquathol® to be effective is 65^{o}F and that's way too late in the season to get good weed control. And that's all I need to say. Thank you. (5)

Response: Comment noted

4. It is unclear what the purpose of introducing diquat use to Washington would be. It is apparent from the risk assessment that it is not selective, and has many deleterious effects on native plants. We see no compelling reason to allow diquat use in our waters. (3)

Response: The agency Advisory Committee, consisting of the Departments of Ecology, Fish and Wildlife, Health, Natural Resources and Agriculture decided to review diquat for use in Washington State for many reasons. Primarily, the agencies are responding to the legislature's request to make as many pesticide products available that are less toxic than others currently allowed for use, such as the aquatic herbicide fluridone. Fluridone, unlike diquat, must be applied at high concentrations in water for a long period of time, which due to exposure time and concentration, makes it more toxic than diquat.

Other reasons why diquat is desired in Washington is because it can be used effectively as a spot treatment, it is removed from the water column relatively quickly via absorption sediment, plants and other organic matter, it is effective on Brazilian elodea, and it is relatively inexpensive.

5. The Washington Toxics Coalition opposes the Department of Ecology's proposal to allow the use of diquat dibromide in aquatic settings. Diquat has known toxicity to birds, amphibians, and invertebrates, is persistent in sediment and soil, and is recognized to be toxic to anadromous fish species. With these limitations, we question the wisdom of allowing its use in water.

   In summary, diquat is extremely persistent and has unacceptable impacts on native plants, fish, and invertebrates. We urge Ecology to deny its use in state waters. (3)

Response: Ecology recognizes the potential impacts that diquat has on native plants, fish, amphibians and invertebrates. As a result, Ecology constructed mitigations to include in the water pollution control permits (NPDES) to avoid harmful impacts. Specifically, sensitive and significant fish species will be protected by a timing table that determines when and where sensitive and significant fish are located at what time of year. A mitigation restricting diquat application within two meters of the shoreline will be included in the permit. Ecology anticipates that such a buffer will decrease the concentration of diquat in shallow water where many aquatic invertebrates, amphibians and nesting birds are found as well as avoid possible contact of diquat to soil. In addition, Ecology will closely monitor the persistence of diquat in sediment and soil following each treatment to determine if the concentration is exceeding a safe level for flora and fauna alike. Native plants and invertebrates are proven to rebound quickly if populations are stressed; therefore Ecology believes that the mitigations in place will be sufficient.

6. Count me out on this one [Bellevue, WA public hearing]. We have had numerous complaints from clients wanting to know why nothing was scheduled in the Olympia area. The meeting places are not appropriate. (6)

Response: Ecology decided that one hearing in western and one in eastern Washington was sufficient. We chose a western location in the north because that is where we recognized the most public interest. No one in the Olympia area requested a local hearing. Ecology will continue to schedule hearings according to request and interest level.

2. Comments on Persistence

7. I have read the Department of Ecology publication titled Focus: Ecology Proposes to Approve the Aquatic Herbicide Diquat Dibromide for Use in Washington State. Just in reading the concerns mentioned in this paper, it would seem that there is not sufficient information about the product diquat dibromide to warrant proceeding with use in our environment. The statement that "Diquat is eliminated from the waterbody quickly..." is in conflict with the statement that "Diquat must be monitored closely because it accumulates in sediment and soil..."

To see this sort of information conflict and not even be looking at the impact paper sets off alarms in my mind. Conclusion: Further study is needed before use. My background is as a horticulturalist and estate manager, for what its worth. (2)

Response: In the statement quoted above, the term "waterbody" refers to the water only (also referred to as the water column). Diquat is removed from the water because it is quickly absorbed by plants, sediment and other suspended debris in the water. Ecology will monitor the accumulation of diquat in sediment in the treatment area following each treatment to determine if concentrations are escalating to harmful levels. Furthermore, Ecology is conducting a local pilot study of an aquatic herbicide treatment with diquat in Battlefield Lake to determine the effects of the proposed mitigations, as well as to monitor the persistence of diquat in the water and sediment of the treated area.

8. Ecology's risk assessment identifies diquat as extremely persistent in soils and sediments, persisting in sediments for at least 356 days. Diquat is also relatively persistent in the water column, with measured time to disappearance of up to 42 days to 65 days. No pesticide should be allowed for use in our state's waters that is likely to persist to this extent. (3)

Response: According to the risk assessment, diquat was persistent in "clear" water (free of organic matter, such as tap water) for up to 65 days. In the natural aquatic environment however, diquat is quickly absorbed by naturally occurring suspended matter, as well as the target plants and benthic sediment. Only in an artificial study, where pure water is involved will diquat persist for up to 65 days. In a natural environment diquat dropped below the detectable limit (0.01 ppm) within 1 to 12 days. Diquat was detected up to 12 days on one occasion where Lake Steilacoom was treated in its entirety. The extended persistence my have been due to the fact the whole lake was treated and was only sparsely covered with plants. In addition, Lake Steilacoom was treated with copper in the past. Although not proven, it is possible that copper, which also binds to sediment, made it difficult for sediment to absorb diquat as well.

3. Human Health

9. Since diquat may persist in water, we are very concerned that there are no restrictions on swimming after an application. Should Ecology approve use of diquat, there should be significant restrictions on swimming after it is applied. (3)

Response: Ecology brought this very question to the Department of Health whom determined: "Persons swimming in water treated with the highest use rate of diquat (0.37 ppm) are not expected to experience significant adverse health effects. Based on the results of the toxicity studies, the product use rates, and the diquat binding properties, systemic toxicity from swimming is very unlikely. The risk assessment shows that a 10 year old child would need to drink massive amounts of water (~ 3.5 gallons), containing 0.37 ppm diquat while swimming for 3 hours to approach the No Observable Adverse Effect Level (NAOEL) dose of 220 mg/kg/d. The only swimming scenario that falls below the target Margin of Safety (MOS) involved a 6 year old child swimming for 3 hours in water assumed to contain the maximum use rate of 0.37 ppm. The target MOS is 100 times less than the chronic NOAEL. In this scenario, the estimated dose absorbed by the child would still be 87 times less than the chronic NOAEL.

Prolonged eye contact with water containing 0.37 ppm diquat may result in the swimmer experiencing some possible chemical-associated temporary minor eye irritation or conjunctivitis. Any redness is expected to remit within a day. As diquat concentration decreases rapidly in water over 24 hours, so would the potential for eye irritation…..Testing may be required to ensure that the EPA's tolerance for diquat dibromide in potable water (0.01 ppm) is not exceeded. Swimmers should be advised of the potential for eye irritation in the first 24 hours following diquat application in water. Swimmers could then chose to avoid the treated area or to wear swim goggles or other eye protection to prevent eye exposure to treated water………science supports that a 24-hour swimming advisory be issued for diquat."

4. Comments on Environmental Effects

10. Despite information contained in the risk assessment showing persistence of diquat in the water column, the risk assessment does not consider chronic toxicity data. Rather, the risk assessment extrapolates from the acute toxicity data. (3)

Response: The evaluation of chronic toxicity to diquat should not be of significant concern because flora and fauna will not be exposed to diquat for long periods of time. Furthermore, diquat is biologically unavailable to animal species and most microbes when bound to sediment and other organic matter shortly after being released into water. In addition, the permit will include a mitigation restricting treatment to twice per season, unless otherwise stated in an Integrated Aquatic Vegetation Management Plan (IVAMP), as well as restricting the use of diquat to the growing season only (may - September). As a result, acute toxicity data is most relevant to anticipated treatments of diquat according to the proposed mitigations.

11. The data considered for fish toxicity indicate a serious concern. The current label for diquat allows concentrations up to 0.75 ppm, and the risk assessment cites LC50 levels of as low as 0.75 ppm (walleye) and 1.5 ppm (smallmouth bass). Thus, it seems highly likely that diquat applications at the label rate will result in fish kills. (3)

Response: Syngenta, the company that produces and markets diquat, is in the process of updating the label for diquat that is likely to be effective in February or March of 2003. The new label will assure that the maximum concentration allowable per application cannot exceed 0.37 ppm. Furthermore, a timing table will be available to applicators to determine at what time of year sensitive and significant species of fish will likely be found in the desired treatment area.

12. Of equal concern is the evidence that diquat can adversely affect salmonids. Diquat at concentrations as low as 0.5 ppm interfered with the downstream migration of Coho smolt. The risk assessment also reports that diquat at 3 ppm produced histopathological effects on the eyes, kidney, gills, and liver. These results indicate that sub lethal effects on salmonids as well as other fish are likely to be significant. (3)

Response: Salmonids will be protected by the fish timing table created by the state Fish and Wildlife Department.

13. A number of invertebrates are also susceptible to diquat exposure. Species likely to be harmed include the amphipod, water flea (Daphnia), pocket shrimp, and apple snail. The risk assessment uses the 48-hour and 96-hour expected environmental concentrations to assess the risk and concludes there is low risk. However, an analysis of the peak exposure, using a simple comparison of the concentration allowed by the label and the LC50 of susceptible species, indicates that invertebrate populations will be adversely affected by diquat application. (3)

Response: Invertebrates populations are proven rebound quickly and diquat cannot be applied within two meters of the shoreline. This will help to protect many invertebrates that live in shallow water.

14. Thought it was interesting in the diquat hearing at Bellevue on Tuesday that you referred to one of the concerns DOE [Ecology] had of diquat. Your concern was that there was a reported incident of wheat seedling inhibition at 5,000 ppm in the soil. I am not sure you realize what 5,000 ppm in the soil means. One acre foot of soil weighs approximately 4,000,000 pounds. Thus 1 pound per acre of a product applied to an acre equals 0.25 ppm. In order to get 5,000 ppm of diquat into the soil it would mean applying 20,000 pounds of diquat per acre or another way to look at it is, diquat (Reward) is a 2 pound per gallon herbicide. That means 10,000 gallons of Reward would have to be applied to the soil to get 5,000 ppm. A truck the size of the one in the attached photo cannot legally carry 10,000 gallons of liquid. I think we can find a whole host of things affecting wheat seedlings at that kind of rate. (5)

Response: Comment noted.

D. Changes to the SEIS

1. Minor changes to language were made throughout the document to update permit and permit coverage information, especially in sections I through IV.
2. Appendices B and C have been added.
3. Responsiveness summary has been added.

Appendix A: Risk Assessments for Diquat Dibromide

Due to size, the risk assessments (publication number 00-10-046) are available as a separate document. Please contact Kathleen Emmett at the Department of Ecology for copies.

Kathleen Emmett
Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600
Telephone: (360) 407-6478
Fax: (360) 407 -6426
E-mail: kemm461@ecy.wa.gov

Appendix B: State Water Pollution Control Laws and Washington's Administrative Codes Governing the Use of Aquatic Pesticides.

Table of Contents

RCW 17.15.010 Integrated Pest Management

Definitions.
The definitions in this section apply throughout this chapter unless the context clearly requires otherwise:

(1) "Integrated pest management" means a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet agency programmatic pest management objectives. The elements of integrated pest management include:

(a) Preventing pest problems;

(b) Monitoring for the presence of pests and pest damage;

(c) Establishing the density of the pest population, that may be set at zero, that can be tolerated or correlated with a damage level sufficient to warrant treatment of the problem based on health, public safety, economic, or aesthetic thresholds;

(d) Treating pest problems to reduce populations below those levels established by damage thresholds using strategies that may include biological, cultural, mechanical, and chemical control methods and that must consider human health, ecological impact, feasibility, and cost-effectiveness; and

(e) Evaluating the effects and efficacy of pest treatments.

(2) "Pest" means, but is not limited to, any insect, rodent, nematode, snail, slug, weed, and any form of plant or animal life or virus, except virus, bacteria, or other microorganisms on or in a living person or other animal or in or on processed food or beverages or pharmaceuticals, which is normally considered to be a pest, or which the director of the department of agriculture may declare to be a pest.

[1997 c 357 § 2.]

RCW 17.15.020 Implementation of Integrated Pest Management Practices

Each of the following state agencies or institutions shall implement integrated pest management practices when carrying out the agency's or institution's duties related to pest control:

(1) The department of agriculture;

(2) The state noxious weed control board;

(3) The department of ecology;

(4) The department of fish and wildlife;

(5) The department of transportation;

(6) The parks and recreation commission;

(7) The department of natural resources;

(8) The department of corrections;

(9) The department of general administration; and

(10) Each state institution of higher education, for the institution's own building and grounds maintenance.

[1997 c 357 § 3.]

RCW 90.48.010 Water Pollution Control Policy Enunciated

It is declared to be the public policy of the state of Washington to maintain the highest possible standards to insure the purity of all waters of the state consistent with public health and public enjoyment thereof, the propagation and protection of wild life, birds, game, fish and other aquatic life, and the industrial development of the state, and to that end require the use of all known available and reasonable methods by industries and others to prevent and control the pollution of the waters of the state of Washington. Consistent with this policy, the state of Washington will exercise its powers, as fully and as effectively as possible, to retain and secure high quality for all waters of the state. The state of Washington in recognition of the federal government's interest in the quality of the navigable waters of the United States, of which certain portions thereof are within the jurisdictional limits of this state, proclaims a public policy of working cooperatively with the federal government in a joint effort to extinguish the sources of water quality degradation, while at the same time preserving and vigorously exercising state powers to insure that present and future standards of water quality within the state shall be determined by the citizenry, through and by the efforts of state government, of the state of Washington.
[1973 c 155 § 1; 1945 c 216 § 1; Rem. Supp. 1945 § 10964a.]

RCW 90.48.260 Federal Clean Water Act - Department Designated as State Agency

Powers, duties and functions.
The department of ecology is hereby designated as the State Water Pollution Control Agency for all purposes of the federal clean water act as it exists on February 4, 1987, and is hereby authorized to participate fully in the programs of the act as well as to take all action necessary to secure to the state the benefits and to meet the requirements of that act. With regard to the national estuary program established by section 320 of that act, the department shall exercise its responsibility jointly with the *Puget Sound water quality authority. The powers granted herein include, among others, and notwithstanding any other provisions of chapter 90.48 RCW or otherwise, the following:

(1) Complete authority to establish and administer a comprehensive state point source waste discharge or pollution discharge elimination permit program which will enable the department to qualify for full participation in any national waste discharge or pollution discharge elimination permit system and will allow the department to be the sole agency issuing permits required by such national system operating in the state of Washington subject to the provisions of RCW 90.48.262(2). Program elements authorized herein may include, but are not limited to: (a) Effluent treatment and limitation requirements together with timing requirements related thereto; (b) applicable receiving water quality standards requirements; (c) requirements of standards of performance for new sources; (d) pretreatment requirements; (e) termination and modification of permits for cause; (f) requirements for public notices and opportunities for public hearings; (g) appropriate relationships with the secretary of the army in the administration of his responsibilities which relate to anchorage and navigation, with the administrator of the

environmental protection agency in the performance of his duties, and with other governmental officials under the federal clean water act; (h) requirements for inspection, monitoring, entry, and reporting; (i) enforcement of the program through penalties, emergency powers, and criminal sanctions; (j) a continuing planning process; and (k) user charges.

(2) The power to establish and administer state programs in a manner which will insure the procurement of moneys, whether in the form of grants, loans, or otherwise; to assist in the construction, operation, and maintenance of various water pollution control facilities and works; and the administering of various state water pollution control management, regulatory, and enforcement programs.

(3) The power to develop and implement appropriate programs pertaining to continuing planning processes, area-wide waste treatment management plans, and basin planning.

The governor shall have authority to perform those actions required of him or her by the federal clean water act. [1988 c 220 § 1; 1983 c 270 § 1; 1979 ex.s. c 267 § 1; 1973 c 155 § 4; 1967 c 13 § 24.]

*Reviser's note: The Puget Sound water quality authority and its powers and duties, pursuant to the Sunset Act, chapter 43.131 RCW, were terminated June 30, 1995, and repealed June 30, 1996. See 1990 c 115 §§ 11 and 12. Powers, duties, and functions of the Puget Sound water quality authority pertaining to cleanup and protection of Puget Sound transferred to the Puget Sound action team by 1996 c 138 § 11. See RCW 90.71.903. Severability -- 1983 c 270: "If any provision of this act or its application to any person or circumstance is held invalid, the remainder of the act or the application of the provision to other persons or circumstances is not affected." [1983 c 270 § 5.]

RCW 90.48.445 Aquatic Noxious Weed Control -- Water Quality Permits

Definition.

(1) The director shall issue or approve water quality permits for use by federal, state, or local governmental agencies and licensed applicators for the purpose of using, for aquatic noxious weed control, herbicides and surfactants registered under state or federal pesticide control laws, and for the purpose of experimental use of herbicides on aquatic sites, as defined in 40 C.F.R. Sec. 172.3. The issuance of the permits shall be subject only to compliance with: Federal and state pesticide label requirements, the requirements of the federal insecticide, fungicide, and rodenticide act, the Washington pesticide control act, the Washington pesticide application act, and the state environmental policy act, except that:

(a) When the director issues water quality permits for the purpose of using glyphosate and surfactants registered by the department of agriculture to control spartina, as defined by RCW 17.26.020, the water quality permits shall contain the following criteria:

(i) Spartina treatment shall occur between June 1st and October 31st of each year unless the department, the department of agriculture, and the department of fish and wildlife agree to add additional dates beyond this period, except that no aerial application shall be allowed on July 4th or Labor Day and for ground application on those days the applicator shall post signs at each corner of the treatment area;

(ii) The applicator shall take all reasonable precautions to prevent the spraying of non-target vegetation and non-vegetated areas;

(iii) A period of fourteen days between treatments is required prior to re-treating the previously treated areas;

(iv) Aerial or ground broadcast application shall not be made when the wind speed exceeds ten miles per hour; and

(v) An application shall not be made when a tidal regime leaves the plants dry for less than four hours.

(b) The director shall issue water quality permits for the purpose of using herbicides or surfactants registered by the department of agriculture to control aquatic noxious weeds, other than spartina, and the permit shall state that aerial and ground broadcast applications may not be made when the wind speed exceeds ten miles per hour.

(c) The director shall issue water quality permits for the experimental use of herbicides on aquatic sites, as defined in 40 C.F.R. Sec. 172.3, when the department of agriculture has issued an experimental use permit, under the authority of RCW 15.58.405(3). Because of the small geographic areas involved and the short duration of herbicide application, water quality permits issued under this subsection are not subject to state environmental policy act review.

(2) Applicable requirements established in an option or options recommended for controlling the noxious weed by a final environmental impact statement published under chapter 43.21C RCW by the department prior to May 5, 1995, by the department of agriculture, or by the department of agriculture jointly with other state agencies shall be considered guidelines for the purpose of granting the permits issued under this chapter. This section may not be construed as requiring the preparation of a new environmental impact statement to replace a final environmental impact statement published before May 5, 1995, but instead shall authorize the department of agriculture, as lead agency for the control of spartina under RCW 17.26.015, to supplement, amend, or issue addenda to the final environmental impact statement published before May 5, 1995, which may assess the environmental impact of the application of stronger concentrations of active ingredients, altered application patterns, or other changes as the department of agriculture deems appropriate.

(3) The director of ecology may not utilize this permit authority to otherwise condition or burden weed control efforts. Except for permits issued by the director under subsection (1)(c) of this section, permits issued under this section are effective for five years, unless a shorter duration is requested by the applicant. The director's authority to issue water quality modification permits for activities other than the application of surfactants and approved herbicides, to control aquatic noxious weeds or the experimental use of herbicides used on aquatic sites, as defined in 40 C.F.R. Sec. 172.3, is unaffected by this section.

(4) As used in this section, "aquatic noxious weed" means an aquatic weed on the state noxious weed list adopted under RCW 17.10.080.

[1999 sp.s. c 11 § 1; 1995 c 255 § 3.]

NOTES: Effective date -- 1999 sp.s. c 11: "This act is necessary for the immediate preservation of the public peace, health, or safety, or support of the state government and its existing public institutions, and takes effect immediately [June 7, 1999]." [1999 sp.s. c 11 § 2.]

Severability -- Effective date -- 1995 c 255: See RCW 17.26.900 and 17.26.901.

RCW 90.48.447 Aquatic Plant Management Program

Commercial herbicide information – Experimental application of herbicides -- Appropriation for study.

(1) The department of ecology shall update the final supplemental environmental impact statement completed in 1992 for the aquatic plant management program to reflect new information on herbicides evaluated in 1992 and new, commercially available herbicides. The department shall maintain the currency of the information on herbicides and evaluate new herbicides as they become commercially available.

(2) For the 1999 treatment season, the department shall permit by May 15, 1999, municipal experimental application of herbicides such as hydrothol 191 for algae control in lakes managed under chapter 90.24 RCW. If experimental use is determined to be ineffective, then the department shall within fourteen days consult with other state, federal, and local agencies and interested parties, and may permit the use of copper sulfate. The Washington institute for public policy shall contract for a study on the lake-wide effectiveness of any herbicide used under this subsection. Prior to issuing the contract for the study, the institute for public policy shall determine the parameters of the study in consultation with licensed applicators who have recent experience treating the lake and with the nonprofit corporation that participated in centennial clean water fund phase one lake management studies for the lake. The parameters must include measurement of the lake-wide effectiveness of the application of the herbicide in maintaining beneficial uses of the lake, including any uses designated under state or federal water quality standards. The effectiveness of the application shall be determined by objective criteria such as turbidity of the water, the effectiveness in killing algae, any harm to fish or wildlife, any risk to human health, or other criteria developed by the institute. The results of the study shall be reported to the appropriate legislative committees by December 1, 1999. A general fund appropriation in the amount of $35,000 is provided to the Washington institute for public policy for fiscal year 1999 for the study required under this subsection.

[1999 c 255 § 2.]

NOTES:

Findings -- Purpose -- 1999 c 255: "The legislature finds that the environmental, recreational, and aesthetic values of many of the state's lakes are threatened by the invasion of nuisance and noxious aquatic weeds. Once established, these nuisance and noxious aquatic weeds can colonize the shallow shorelines and other areas of lakes with dense surface vegetation mats that degrade water quality, pose a threat to swimmers, and restrict use of lakes. Algae can generate health and safety conditions dangerous to fish, wildlife, and humans. The current environmental impact statement is causing difficulty in responding to environmentally damaging weed and algae problems. Many commercially available herbicides have been demonstrated to be effective in controlling nuisance and noxious aquatic weeds and algae and do not pose a risk to the environment or public health. The purpose of this act is to allow the use of commercially available herbicides that have been approved by the environmental protection agency and the department of agriculture and subject to rigorous evaluation by the department of ecology through an environmental impact statement for the aquatic plant management program." [1999 c 255 § 1.]

Effective date -- 1999 c 255: "This act is necessary for the immediate preservation of the public peace, health, or safety, or support of the state government and its existing public institutions, and takes effect immediately [May 10, 1999]." [1999 c 255 § 5.]

RCW 90.48.448 Eurasian Water milfoil - Pesticide 2,4-D Application

(1) Subject to restrictions in this section, a government entity seeking to control a limited infestation of Eurasian water milfoil may use the pesticide 2,4-D to treat the milfoil infestation, without obtaining a permit under RCW 90.48.445, if the milfoil infestation is either recently documented or remaining after the application of other control measures, and is limited to twenty

percent or less of the littoral zone of the lake. Any pesticide application made under this section must be made according to all label requirements for the product and must meet the public notice requirements of subsection (2) of this section.

(2) Before applying 2,4-D, the government entity shall: (a) Provide at least twenty-one days' notice to the department of ecology, the department of fish and wildlife, the department of agriculture, the department of health, and all lake residents; (b) post notices of the intent to apply 2,4-D at all public access points; and (c) place informational buoys around the treatment area.

(3) The department of fish and wildlife may impose timing restrictions on the use of 2,4-D to protect salmon and other fish and wildlife.

(4) The department may prohibit the use of 2,4-D if the department finds the product contains dioxin in excess of the standard allowed by the United States environmental protection agency. Sampling protocols and analysis used by the department under this section must be consistent with those used by the United States environmental protection agency for testing this product.

(5) Government entities using this section to apply 2,4-D may apply for funds from the freshwater aquatic weeds account consistent with the freshwater aquatic weeds management program as provided in RCW 43.21A.660.

(6) Government entities using this section shall consider development of long-term control strategies for eradication and control of the Eurasian water milfoil.

(7) For the purpose of this section, "government entities" includes cities, counties, state agencies, tribes, special purpose districts, and county weed boards.

[Statutory Authority: Chapter 90.48 RCW and 40 CFR 131. 97-23-064 (Order 94-19), § 173-201A-110, filed 11/18/97, effective 12/19/97. Statutory Authority: Chapter 90.48 RCW. 92-24-037 (Order 92-29), § 173-201A-110, filed 11/25/92, effective 12/26/92.]

WAC 173-201A-110 Short-Term Water Quality Modifications

The criteria and special conditions established in WAC 173-201A-030 through 173-201A-140 may be modified for a specific water body on a short-term basis when necessary to accommodate essential activities, respond to emergencies, or to otherwise protect the public interest, even though such activities may result in a temporary reduction of water quality conditions below those criteria and classifications established by this regulation. Such activities must be conditioned, timed, and restricted (i.e., hours or days rather than weeks or months) in a manner that will minimize water quality degradation to existing and characteristic uses. In no case will any degradation of water quality be allowed if this degradation significantly interferes with or becomes injurious to characteristic water uses or causes long-term harm to the environment.

(1) A short-term modification may be issued in writing by the director or his/her designee to an individual or entity proposing the aquatic application of pesticides, including but not limited to those used for control of federally or state listed noxious and invasive species, and excess populations of native aquatic plants, mosquitoes, burrowing shrimp, and fish, subject to the following terms and conditions:

(a) A short-term modification will in no way lessen or remove the project proponent's obligations and liabilities under other federal, state and local rules and regulations.

(b) A request for a short-term modification shall be made to the department on forms supplied by the department. Such request shall be made at least thirty days prior to initiation of the proposed activity, and after the project proponent has complied with the requirements of the State Environmental Policy Act (SEPA);

(c) A short-term modification shall be valid for the duration of the activity requiring modification of the criteria and special conditions in WAC 173-201A-030 through 173-201A-140, or for one year, whichever is less. Ecology may authorize a longer duration where the activity is part of an ongoing or long-term operation and maintenance plan, integrated pest or noxious weed management plan, waterbody or watershed management plan, or restoration plan. Such a plan must be developed through a public involvement process consistent with the Administrative Procedure Act (chapter 34.05 RCW) and be in compliance with SEPA, chapter 43.21C RCW, in which case the standards may be modified for the duration of the plan, or for five years, whichever is less;

(d) Appropriate public notice as determined and prescribed by the director or his/her designee shall be given, identifying the pesticide, applicator, location where the pesticide will be applied, proposed timing and method of application, and any water use restrictions specified in USEPA label provisions;

(e) The pesticide application shall be made at times so as to:

(i) Minimize public water use restrictions during weekends; and

(ii) Avoid public water use restrictions during the opening week of fishing season, Memorial Day weekend, Independence Day weekend, and Labor Day weekend;

(f) Any additional conditions as may be prescribed by the director or his/her designee.

(2) A short-term modification may be issued for the control or eradication of noxious weeds identified as such in accordance with the state noxious weed control law, chapter 17.10 RCW, and Control of spartina and purple loosestrife, chapter 17.26 RCW. Short-term modifications for noxious weed control shall be included in a water quality permit issued in accordance with RCW 90.48.445, and the following requirements:

(a) Water quality permits for noxious weed control may be issued to the Washington state department of agriculture (WSDA) for the purposes of coordinating and conducting noxious weed control activities consistent with their responsibilities under chapter 17.10 and 17.26 RCW. Coordination may include noxious weed control activities identified in a WSDA integrated noxious weed management plan and conducted by individual landowners or land managers.

(b) Water quality permits may also be issued to individual landowners or land managers for noxious weed control activities where such activities are not covered by a WSDA integrated noxious weed management plan.

(3) The turbidity criteria established under WAC 173-201A-030 shall be modified to allow a temporary mixing zone during and immediately after necessary in-water or shoreline construction activities that result in the disturbance of in-place sediments. A temporary turbidity mixing zone is subject to the constraints of WAC 173-201A-100 (4) and (6) and is authorized only after the activity has received all other necessary local and state permits and approvals, and after the implementation of appropriate best management practices to avoid or minimize disturbance of in-place sediments and exceedances of the turbidity criteria. A temporary turbidity mixing zone shall be as follows:

(a) For waters up to 10 cfs flow at the time of construction, the point of compliance shall be one hundred feet downstream from activity causing the turbidity exceedance.

(b) For waters above 10 cfs up to 100 cfs flow at the time of construction, the point of compliance shall be two hundred feet downstream of activity causing the turbidity exceedance.

(c) For waters above 100 cfs flow at the time of construction, the point of compliance shall be three hundred feet downstream of activity causing the turbidity exceedance.

(d) For projects working within or along lakes, ponds, wetlands, estuaries, marine waters or other non-flowing waters, the point of compliance shall be at a radius of one hundred fifty feet from activity causing the turbidity exceedance.

WAC 173-201A-030 (5) Characteristic Uses for Lake Class Waters

(a) General characteristic. Water quality of this class shall meet or exceed the requirements for all or substantially all uses.

(b) Characteristic uses. Characteristic uses shall include, but not be limited to, the following:

(i) Water supply (domestic, industrial, agricultural).

(ii) Stock watering.

(iii) Fish and shellfish:

Salmonid migration, rearing, spawning, and harvesting.

Other fish migration, rearing, spawning, and harvesting.

Clam and mussel rearing, spawning, and harvesting.

Crayfish rearing, spawning, and harvesting.

(iv) Wildlife habitat.

(v) Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment).

(vi) Commerce and navigation.

(c) Water quality criteria:

(i) Fecal coli form organism levels shall both not exceed a geometric mean value of 50 colonies/100 mL, and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 100 colonies/100 mL.

(ii) Dissolved oxygen - no measurable decrease from natural conditions.

(iii) Total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection.

(iv) Temperature - no measurable change from natural conditions.

(v) pH - no measurable change from natural conditions.

(vi) Turbidity shall not exceed 5 NTU over background conditions.

(vii) Toxic, radioactive, or deleterious material concentrations shall be below those which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health, as determined by the department (see WAC 173-201A-040 and 173-201A-050.

(viii) Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.

(6) **Establishing lake nutrient criteria.**

(a) The following table shall be used to aid in establishing nutrient criteria:

Lakes in the Willamette, East Cascade Foothills, or Blue Mountain ecoregions do not have recommended values and need to have lake-specific studies in order to receive criteria as described in (c)(i) of this subsection.

(b) The following actions are recommended if ambient monitoring of a lake shows the epilimnetic total phosphorus concentration, as shown in Table 1 of this section, is below the action value for an ecoregion:

(i) Determine trophic status from existing or newly gathered data. The recommended minimum sampling to determine trophic status is calculated as the mean of four or more samples collected from the epilimnion between June through September in one or more consecutive years. Sampling must be spread throughout the season.

(ii) Propose criteria at or below the upper limit of the trophic state; or

(iii) Conduct lake-specific study to determine and propose to adopt appropriate criteria as described in (c) of this subsection.

(c) The following actions are recommended if ambient monitoring of a lake shows total phosphorus to exceed the action value for an ecoregion shown in Table 1 of this section or where recommended ecoregional action values do not exist:

(i) Conduct a lake-specific study to evaluate the characteristic uses of the lake. A lake-specific study may vary depending on the source or threat of impairment. Phytoplankton blooms, toxic phytoplankton, or excessive aquatic plants, are examples of various sources of impairment. The following are examples of quantitative measures that a study may describe: Total phosphorus, total nitrogen, chlorophyll-a, dissolved oxygen in the hypolimnion if thermally stratified, pH, hardness, or other measures of existing conditions and potential changes in any one of these parameters.

(ii) Determine appropriate total phosphorus concentrations or other nutrient criteria to protect characteristic lake uses. If the existing total phosphorus concentration is protective of characteristic lake uses, then set criteria at existing total phosphorus concentration. If the existing total phosphorus concentration is not protective of the existing characteristic lake uses, then set criteria at a protective concentration. Proposals to adopt appropriate total phosphorus criteria to protect characteristic uses must be developed by considering technical information and stakeholder input as part of a public involvement process equivalent to the Administrative Procedure Act (chapter 34.05 RCW).

(iii) Determine if the proposed total phosphorus criteria necessary to protect characteristic uses is achievable. If the recommended criterion is not achievable and if the characteristic use the criterion is intended to protect is not an existing use, then a higher criterion may be proposed in conformance with 40 CFR part 131.10.

(d) The department will consider proposed lake-specific nutrient criteria during any water quality standards rule making that follows development of a proposal. Adoption by rule formally establishes the criteria for that lake.

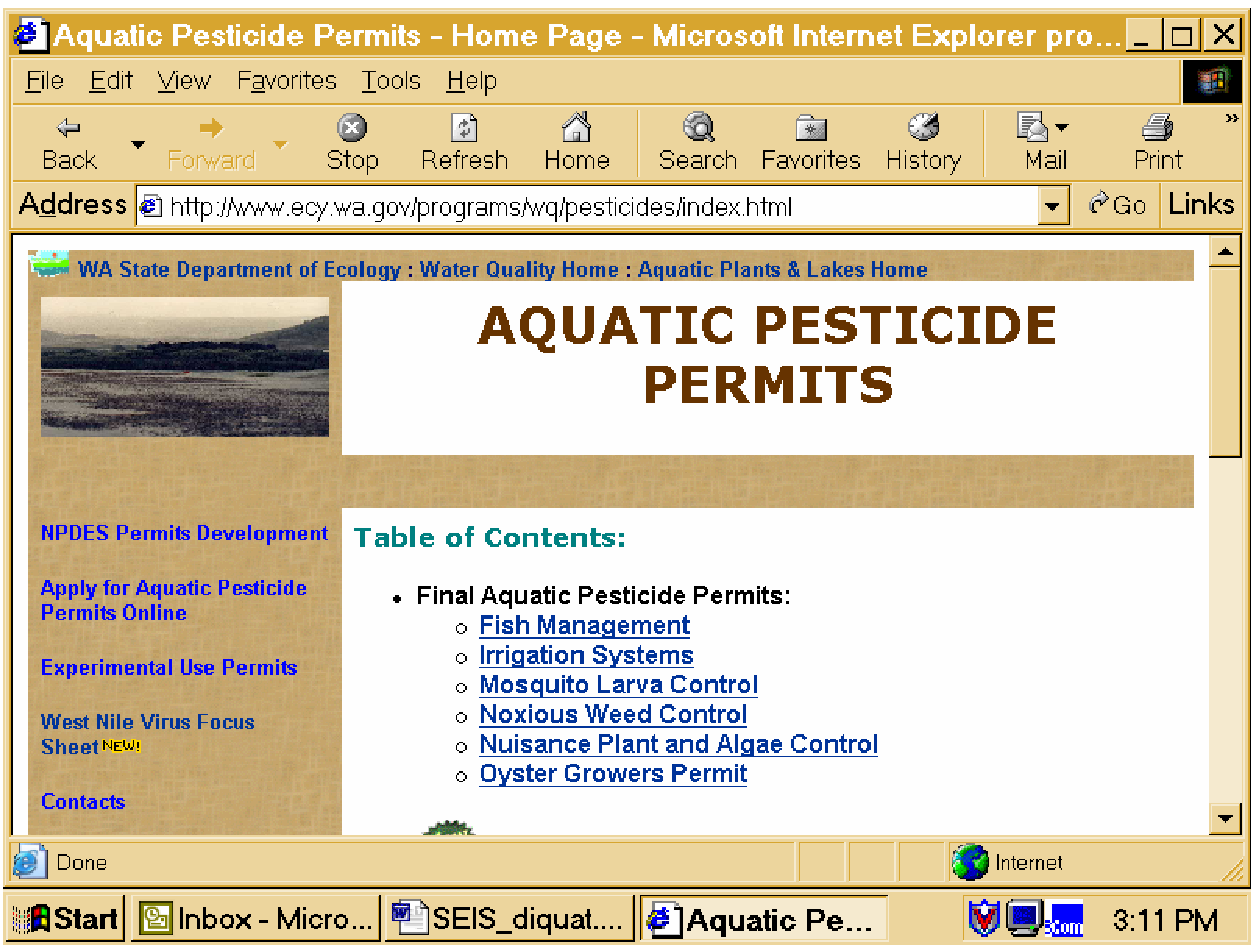
(e) Prioritization and investigation of lakes by the department will be initiated by listing problem lakes in a watershed needs assessment, and scheduled as part of the water quality program's watershed approach to pollution control. This prioritization will apply to lakes identified as warranting a criteria based on the results of a lake-specific study, to lakes warranting a lake-specific study for establishing criteria, and to lakes requiring restoration and pollution control measures due to exceedance of an established criterion. The adoption of nutrient criteria are generally not intended to apply to lakes or ponds with a surface area smaller than five acres; or to ponds wholly contained on private property owned and surrounded by a single landowner; and nutrients do not drain or leach from these lakes or private ponds to the detriment of other property owners or other water bodies; and do not impact designated uses in the lake. However, if the landowner proposes criteria the department may consider adoption.

(f) The department may not need to set a lake-specific criteria or further investigate a lake if existing water quality conditions are naturally poorer (higher TP) than the action value and uses have not been lost or degraded, per WAC 173-201A-070(2).

Statutory Authority: Chapter 90.48 RCW and 40 CFR 131. 97-23-064 (Order 94-19), § 173-201A-030, filed 11/18/97, effective 12/19/97. Statutory Authority: Chapter 90.48 RCW. 92-24-037 (Order 92-29), § 173-201A-030, filed 11/25/92, effective 12/26/92.]

Appendix C: Links and Contacts to Aquatic Plant Control General Permit Applications

The screen below is the Department of Ecology's web site regarding aquatic herbicides. Follow the link illustrated in the address bar below to utilize the web site.



For hardcopies of the permits and information about the discharge permit process for aquatic pesticides, please contact:

Kathleen Emmett
Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600
Telephone: (360) 407-6478
Fax: (360) 407 -6426
E-mail: kemm461@ecy.wa.gov

Ecology Regional Contacts

Central Regional Office (Yakima)	Ray Latham Phone: (509) 575-2807 E-mail: rlat461@ecy.wa.gov
Eastern Regional Office (Spokane)	Nancy Weller Phone: (509) 625-5194 E-mail: nwel461@ecy.wa.gov
Northwest Regional Office (Bellevue)	Tricia Shoblom Phone: (425) 649-7288 E-mail: tsho461@ecy.wa.gov
Southwest Regional Office (Olympia)	Kerry Carroll Phone: (360) 407-6294 E-mail: kcar461@ecy.wa.gov

Ecology Noxious Weed Permitting Contact

Statewide Contact (Olympia)	Kathy Hamel Phone: (360) 407-6562 E-mail: kham461@ecy.wa.gov

Department of Agriculture Noxious Weed Contacts

Noxious Weeds in Lakes	Clinton Campbell Phone: (360) 902-2071 E-mail: CCampbell@agr.wa.gov
Noxious Freshwater Emergents	Greg Haubrich Phone: (509) 225-2604 E-mail: ghaubrich@agr.wa.gov
Spartina	Kyle Murphy Phone: (360) 902-1923 E-mail: KMurphy@agr.wa.gov

Other Department of Agriculture Contacts

Before applying any aquatic herbicide, the applicator must obtain a pesticide applicator license and an aquatics endorsement through the Department of Agriculture (WSDA), Pesticide Management Division, Program Development (http://www.wa.gov/agr/AboutWSDA/Divisions/PesticideMgmt.htm#ProgramDevelopment).

Western Washington WSDA	Pesticide Licensing and Recertification Phone: (360) 902-2020
Eastern Washington WSDA	Pesticide Licensing and Recertification Phone: (509) 225-2639