WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Environmental Impact Statement (EIS) for Permitted Use of Triclopyr

Final

May 2004
Publication Number 04-10-018 revised

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Washington State Department of Ecology
Water Quality Program

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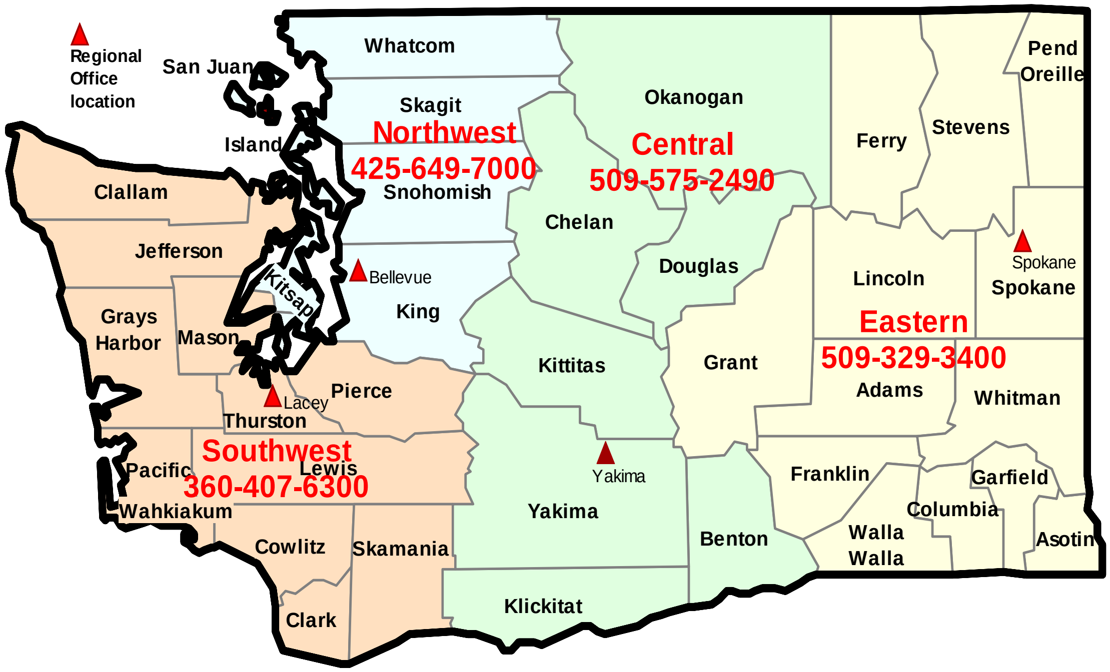

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Fact Sheet

Project Title:	State of Washington Aquatic Plant Management Program
Proposed Action:	The proposed action is the supplemental review of triclopyr herbicide for aquatic plant management. The action is defined as a nonproject proposal under State Environmental Policy Act (SEPA) rules such that the Environmental Impact Statement (EIS) will be integrated with on-going agency planning and permitting procedures for aquatic herbicides. The Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management was completed by Ecology's Water Quality Program February 2001 (Publication No. 00-10-040). The current evaluation for triclopyr is a supplement to that Environmental Impact Statement. 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 include no action, which is the continuation of current policy.
Lead Agency:	Washington State Department of Ecology
Responsible Official:	Melissa Gildersleeve, Watershed Management Section Manager
Contact Person:	Kathleen Emmett, Water Quality Program
Licenses, Permits:	Not all permits listed below are required. Requirements may change; please check with resource agencies to determine permit requirements for a particular project.
Ecology:	Coverage under the Aquatic Nuisance Plant and Algae Control Permit No. WAG-994000 and/or the Aquatic Noxious Weed Control NPDES Permit No. 993000.
Local:	Substantial Development Permit (Shorelines Management Act) in certain locales.
Authors:	Kathleen Emmett and Laurie Morgan, Washington State Department of Ecology, P.O. Box 47600, Olympia, WA 98504-7600. Triclopyr risk assessment data , Study No. 00713, was contracted from Bernalyn D. McGaughey, Risk Assessment Project Manager, Compliance Services International, 1112 Alexander Avenue E. Tacoma, Washington 8421.

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Location of Backgrond Data:	Water Quality Program Department of Ecology P.O. Box 47600 Olympia, WA 98504-7600

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Summary

Aquatic plants are a valuable component of aquatic ecosystems that in normal situations require protection. They provide cover, habitat, and food for many species of aquatic biota, fish and wildlife. However, they can 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 excessive native and noxious aquatic plant species in various water bodies. 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. The Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management was completed by Ecology's Water Quality Program February 2001 (Publication No. 00-10-040). The current evaluation for triclopyr is a supplement to that Environmental Impact Statement.

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 and shellfish migration, 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.

New chemical control methods for aquatic plants continue to evolve. In order to assess the use of new or improved products in Washington State, the 1999 Legislature directed Ecology to expand certain chemical application sections of the 1992 SEIS. The legislature also directed Ecology 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).

To accomplish this task, Ecology initiated a SEPA environmental review process to supplement the 1992 SEIS. Ecology is the primary lead for the supplemental updates to the SEIS. 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. The Washington State Department of Agriculture (WSDA) is charged with regulating pesticide applicators, registering pesticides for use in the state, and, along with the state Noxious Weed Control Board, with controlling noxious plants within the state. The Department of Health is charged with protection of human health. The Department of Fish and

Wildlife has received requests for Hydraulic Project Approvals (HPAs) to implement various physical and mechanical methods and is charged with protecting fish and wildlife. The Departments of Natural Resources and Ecology also have concerns with the potential impact of various plant control methods on the natural resources they are charged with managing. The Departments of Fish and Wildlife and Natural Resources have also been mandated by the legislature to develop programs for controlling particular noxious emergent species on state-owned or managed lands.

In the fall of 1999, Ecology initiated the development of risk assessments regarding use of specific herbicide applications to provide technical support for the updates to the 1992 SEIS. The risk assessments discuss the characterization and environmental fate as well as the environmental and human health effects of six herbicides. The first set of risk assessments, completed May 2000, evaluated 2,4-D formulations registered for aquatic use by the state and endothall formulations Hydrothol 191 and Aquathol. The second set of assessments, completed in 2001, evaluated diquat, triclopyr, and copper compounds.

The assessments provide information for the environmental checklist required by SEPA. Application conditions that minimize or mitigate adverse human health and environmental impacts, are explored and in some cases (i.e. swimming restrictions on endothall) have changed from those required in the 1992 SEIS to reflect new information concerning the impacts of the product. The herbicides assessed were selected by the agency steering committee for update of the 1992 Aquatic Plant SEIS on the basis of registration status, desirability for use, and direction from Senate Substitute Bill 5424 (1999).

Special consideration is given to salmonids and other listed species under the Endangered Species Act (ESA). 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 potential impacts and toxicity of one-time and repeated applications of each herbicide on numbers, diversity, and habitat of species of plants, fish, birds, and other wildlife is 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.

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 functional value or acreage. 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. Use of an integrated management approach will further this goal through the selection of the control method or combination of methods that will effect maximum aquatic plant control while minimizing undesirable impacts to human and environmental health.

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 your 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 permit or permit coverage 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
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- 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 MMdifications
- WAC 173-201A-030 Lake Class Water Quality Criteria

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. Ecology regional offices issue site-specific permits for the use of the aquatic herbicides based on this guidance. The current final SEIS supplements the 2001 SEIS and provides guidance for IPM control methods, which may include the use of aquatic herbicides.

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.

The WSDA must license applicators for all aquatic pesticide applications. Each licensed applicator must follow permit requirements.

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 water body proposed for treatment is part of a designated critical habitat of an ESA listed species or if the water body 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 staffs 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, diquat, and triclopyr. 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 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).

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Alternative Aquatic Plant Management Methods

1. 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 the herbicide triclopyr 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 in 2004. Glyphosate is expected to be evaluated in 2004. 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 triclopyr 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 triclopyr in the chemical methods section, the information on integrated, biological, mechanical, and manual methods of aquatic vegetation control are included.

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
4. Use of biological methods only
5. Use of chemical methods (the proposed action)

2. 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, fishing, aesthetic enjoyment; public water supply, stock watering, fish and shellfish rearing, spawning, harvesting, wildlife habitat, commerce, and navigation.

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.
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.

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.

3. 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.
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.

4. 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. 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.

5. 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.

    - 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 alternate 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 three years, or successful breeding of three species of native amphibians)".
  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.

6. 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, 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, 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

The Preferred Alternative - An Integrated Aquatic Vegetation Management Plan

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

The current preferred alternative is based on the 2001 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 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 water body 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 2001 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 cannot 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 completely 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.
> (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 water body. 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.

2. 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 water bodies 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 water body and what they consider as 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 is 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 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 together 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 that 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 water body,
- 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 water body 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 water body 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 water body 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. Although dozens of plant species may exist in a given water body, 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 water body 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 water body.

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 water body. Water body 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 water body 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 the Department of 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 water body 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 water body 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 water bodies 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 more extreme measures 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? 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 water body 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 factor 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 plan 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 water body 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.

3. 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 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 contains 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.

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The No Action Alternative: Continuing Current Practices

1. 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.

2. 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:

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
- 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 water body. 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 and again in 2001. 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 2001 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 2001 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.

Mechanical and Manual Alternatives

1. 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.

2. 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 one year up to ten 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.

A. 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 (one to two 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.

B. 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 un-vegetated sites within three days of barrier placement and only minor volumes were collected after eight 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 two to three 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 two-thirds 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 an 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.

C. 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 water body. 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.

3. 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 percent 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.

A. 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.

B. 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 water body. 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 water body 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 because 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 U.S. 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 an 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 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.

C. 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 water body, 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 the 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.

4. Hand Removal, Cutting, and Raking

A. 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 accomplished best 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.

B. 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 an 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.

C. 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 require 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 affect 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.

5. 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 two acres to less than one 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 percent to 97 percent 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) here 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 water bodies where Eurasian water milfoil fully occupies its ecological niche. Otherwise, rotovation could tend to spread Eurasian water milfoil throughout the water body 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 permit. Ecology requires a temporary modification of water quality standards issued by the regional offices, and a Hydraulic Project Approval is required from WDFW. Any priority, threatened or endangered species need to be identified. In addition, the U.S. Army Corps of Engineers requires a section 404 permit.

A. Impacts Due to Rotovation

Earth

Sediments. The rotovator's tiller head can penetrate sediment to a depth ranging from seven to nine 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 because 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 two and a half 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 five 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 characterize accurately 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 affect 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 affect 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 an 80 percent to 97 percent 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 affect 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 eliminated temporarily. 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.

B. 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 water body. Ecology requires a permit, counties, and cities sometimes require a shoreline permit. 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 in a way 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 is 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 water body. 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.

6. 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 percent 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.

A. 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 Long Lake. Harvesting can be a nutrient management technique in shallow eutrophic systems.

Mechanical Plant Cutters. Two commercial types of mechanical underwater plant cutters are available. Portable boat mounted cutting Uuits are portable boat-mounted cutters that can be installed on a fourteen-foot or longer boat and are 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 ten inches and as deep as five 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. Generally, cutting is 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.

B. 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 six 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 percent of submersed plants in Halverson Lake killed 2100 fish per acre harvested, or about 25 percent 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 percent (in June) and 11 percent (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. They 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 are 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.

C. 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.

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.

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Biological Methods Only as an Alternative

1. 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 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 water body. The Washington Department of Fish and Wildlife determines the appropriate stocking rate for each water body 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 water bodies 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 water bodies 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 water body 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 water body. 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 percent to 40 percent 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 water body 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 water body, they can only be removed with very great difficulty. A rotenone bait was recently registered which can remove about 1one-third 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.

2. 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.

3. 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 water bodies 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.

4. 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.

5. 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.)

6. 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.

7. 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.

A. 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° 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° F, while feeding diminishes below 53° 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° F but below 90° F. Grass carp can survive a wide range of temperatures from freezing to 95° 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 U.S. Army Corps of Engineers, U.S. 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.

B. 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 affect 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:

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

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 that 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 water body. 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 eight 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 eight 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 ten 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 affect 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 U.S. 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 an 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.

C. 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 water body. If inlets or outlets require screening prior to the introduction of grass carp, an 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 U.S. 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 water body 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 water body size threshold and the agency has received permit applications for larger water bodies. WDFW's policy states that Ecology must approve applications to water bodies 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 water bodies 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 water body 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.

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Use of Chemicals as an Alternative

1. Introduction to Chemical Control Methods

Ecology permits the use of aquatic herbicides that do not cause unreasonable adverse impacts, including prolonged water use restrictions. The proposal is to add triclopyr to the list of permitted herbicides.

The information on triclopyr reviewed in this SEIS is brief, concise, and not overly technical. Analysis and evaluation of triclopyr is based primarily on technical review found in the risk assessments supporting them and is simply summarized herein.

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.
- A reference to the supporting appendix or a complete bibliography of citations is presented at the end the herbicide review.

2. 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.

3. 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 to 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.

4. 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).

5. 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 section on triclopyr supplies the general and special conditions found in Ecology's aquatic plant control permits. Permit conditions are also supplemented by public notice procedures.

Triclopyr Herbicide

The purpose of this Supplemental Environmental Impact Statement is to review what is known about the potential environmental effects of aquatic uses of triclopyr. This includes a summary of the registration status, environmental effects, potential human health impacts, and recommended mitigation to minimize the effects of triclopyr application. This information is designed to follow closely the State Environmental Protection Act (SEPA) Checklist. Except where otherwise noted, references to the 2001 triclopyr risk assessment prepared for Ecology by Compliance Services International (CSI) Volume 5 Triclopyr, Sections 1 – 5. Mitigations for the use of triclopyr in Washington waters that go beyond label conditions are bulleted in each section and summarized at the end of this document.

1. Registration Status

Triclopyr TEA (triethylamine) was first registered by Dow AgroSciences on May 8, 1979 as an herbicide on non-crop areas and in forestry use for the control of broadleaf weeds and woody plants. In 1984, it was registered for use on turf sites. In 1995, triclopyr TEA was registered for use on rice to control many hard to control broadleaf weed species. EPA's Re-registration Eligibility Decision (RED) process for triclopyr acid, triclopyr TEA and triclopyr BEE (butoxyethyl ester) was completed on September 30, 1997. The on-line RED can be viewed at http://www.epa.gov/oppsrrd1/REDs/2710red.pdf.

Garlon® 3A (EPA Reg. No. 62719-37) from Dow AgroScience is currently registered in the state of Washington for the control of aquatic weeds in public water ways and annual and perennial broadleaf weeds and woody brush in wetlands.

November 2002, SePRO Corporation received Federal EPA registration for Triclopyr TEA salt under the trade name (EPA Reg. No. 62719-37-67690). The Renovate® label specifies selective control of nuisance and exotic plants such as Eurasian watermilfoil (*Myriophyllum spicatum*), purple loosestrife (*Lythrum salicaria*), alligatorweed (*Alternanthera philoxeroides*), and water hyacinth (*Eichhornia crassipes*).

DowElanco currently manufactures and distributes Garlon® 3A and SEPRO Corporation will market and distribute Renovate® under a separate label. The products will be the same since DowElanco will manufacture both products.

2. Description

What Triclopyr is used for

Triclopyr, ((3,5,6-tricholoro-2-pyridinyl) oxyacetic acid) is an aquatic herbicide that utilizes a systemic mode of action used to control submerged, floating and emergent aquatic plants in both static and flowing water. It is also registered for a number of terrestrial uses including broadleaf weed control, and is used in rice, pasture and rangeland, rights-of-way, forestry, turf, and home lawns and gardens.

Other Ingredients in the Triclopyr Formulation

Triclopyr is formulated as a solution in water. Intentionally added inert or "other" ingredients in triclopyr formulations include water and triethanol amine (TEA). The water serves as the primary diluent/solvent in the liquid product while the triethanol amine is used to form the salt of the technical grade active ingredient. There are no known impurities identified by the manufacturers or the US EPA that are known to be of toxicological or environmental concern.

How Triclopyr Works

Triclopyr is a growth hormone of the *auxin* type. An auxin-type herbicide interferes with growth after the plant emerges. It contacts leaves, where sugar is produced, and moves to roots, tips, and parts of the plant that store energy, thereby interrupting growth. Since the movement of sugars from the leaves to other parts of the plant is essential for growth, this type of herbicide has the potential to kill simple perennial and creeping perennial weeds with only one or two foliar applications. Bending and twisting of leaves and stems is evident almost immediately after application. Delayed symptom development includes root formation on dicot stems: misshapen leaves, stems and flowers; and abnormal roots (EPA, 1998) (Purdue, 2000).

What Target Aquatic Plants Triclopyr Affects

Triclopyr has been claimed to be effective for a variety of fully or partially aquatic plants including American lotus (*Nelumbo lutea*), Eurasian watermilfoil (*Myriophyllum spicatum*), parrotfeather (*Myriophyllum aquaticum*), pennywort (*Hydrocotyle* spp.), waterhyacinth (*Eichhornia crassipes*), water lilies (*Nuphar* spp. and *Nymphaea odorata*) and waterprimrose (*Ludwigia uruguayenis*), alligatorweed (*Alternanthera philoxeroides*) and purple loosestrife (*Lythrum salicaria*).

What Aquatic Plants Triclopyr Does Not Affect

Triclopyr is not typically used for algae control and most species of algae are not affected strongly by triclopyr (Section 4, Tables 2, 11 and 16). Many species of native plants are not affected by triclopyr or are not affected except transitorily. Some of these may include pondweed species and coontail, rushes and cattails (Petty et al, 1998). However, at higher use rates (2.5 ppm a.e.), the more susceptible native species such as coontail, Southern naiad, and American waterweed may be reduced in numbers in some treatment situations.

Physical and Chemical Characteristics of Triclopyr

Triclopyr dissolves readily in water but is not volatile. It has a low vapor pressure (1.26x 10^{-6} mm/Hg at 25° C for the active ingredient triclopyr), and a low distribution coefficient (0.165 to 0.925 mL/g). *Hydrolysis* refers to the chemical interaction of the chemical with water as a mechanism of chemical breakdown. Triclopyr acid, which forms immediately when Triclopyr TEA dissolves in water, is not hydrolyzed.

Degradation Mechanisms and Products

The main degradation products of triclopyr in the environment occur because of photolysis or microbial degradation.

- *Photolysis*

  Photolysis, or chemical breakdown due to sunlight, can contribute substantially to the degradation of triclopyr acid and triclopyr TEA. These triclopyr products are degraded rapidly under natural sunlight (0.6 to 6.6 days) with both the dominant degradate and degradation rate varying somewhat with the product tested (EPA RED, 1998).

  In sterile buffered water, photolysis of triclopyr acid (dissociated triclopyr TEA) produced MDPA (5-chloro-3, 6-dihydroxy-2-pyridinyloxyacetic acid) with small amounts of oxamic acid and carbon dioxide [EPA RED (1995) p. 53 and Woodburn et al (1993)]. In natural river water, photolysis produced mainly oxamic acid.

- *Microbial Degradation*

  In aerobic soils, triclopyr degrades to carbon dioxide. Intermediate degradation products include TCP *(3,5,6-trichloro-2-pyridinol)* and TMP *(3,5,6 tricloro-2- methoxypyridine)*.

Persistence

The persistence of triclopyr and its degradates varies widely depending on the conditions of the system being tested. For the most part, triclopyr is dissipated rapidly from the water column and is not adsorbed on sediment for very long periods of time.

In soils, factors that affect persistence of triclopyr include temperature, pH, higher organic matter content, higher microbial numbers, and the presence of triclopyr due to previous applications. Half-life persistence can range from less than one day to nearly a year (Section 3, Table 3.4, p. 31). A Dow AgroSciences product (trade name Confront, containing 33% Triclopyr TEA) was not broken down by composting operations produced at a publicly owned solid waste facility in Spokane County, Washington, where it tainted at least 47,000 cubic yards of compost. The presence of the herbicide Confront rendered the compost damaging to crops and resulted in several claims against the waste facility. It is unknown whether triclopyr or the herbicide's other active ingredient, clopyralid triethylamine salt (12.1%) was at fault for contaminating the compost (See: County wants Dow Chemical to stop distributing herbicide, The Spokesman Review, Spokane, WA, 4/25/01).

Persistence in water

The environmental persistence of triclopyr products in the field can be quite variable; the dissipation half-life in water varies from less than one day to approximately seven and one-half days. However, according to most authors, the most typical half-life would be between three and one-half days and seven and one-half days (CSI, Volume 5, Section 3, Table 3.5, p. 55). Dissipation of triclopyr is primarily due to photolysis, degradation by microbes, and mixing of triclopyr treated water with water that has not been treated.

Dissipation is related to lake size, wind, and the amount of water exchange that occurs. The larger the lake, the more wind blowing across the lake surface, the more water exchange through inlet and outlet streams or rivers, the more likely it is that triclopyr residues will be rapidly dispersed and diluted to below detection limits. In small lakes, detectable concentrations of triclopyr may be carried a significant distance down an outlet stream if the flow is sufficient and degradation is slow.

The concentration of the toxic metabolite (TCP) has generally been low in lake and pond water with concentrations of TCP not higher than ~0.1 ppm in Lake Minnetonka, Lake Seminole, and various ponds on the day of application. It generally dissipates to concentrations below the detection limit at three days after treatment.

Persistence in water - anaerobic conditions

Anaerobic environments lack oxygen. According to studies, triclopyr in anaerobic aquatic sediment may have a very long half-life. For example, it can take a year for 20 percent of the amount of triclopyr to degrade in these environments. The calculated rate for 50 percent to degrade is about three and one-half years.

Persistence on sediments

In the Lake Minnetonka study, the half-lives of triclopyr in the sediment ranged from around five or six days at Lake Minnetonka, and the sediment half lives of TCP were approximately eleven days.

Persistence in aerobic soil

Laboratory studies indicate that triclopyr acid and the dissociated triethylamine (TEA) are readily degraded in aerobic soil. The half-lives of triclopyr acid and triclopyr TEA can vary from just a few days in laboratory aerobic soil metabolism experiments to approximately two weeks on Northern Ontario forest soils to nearly three months in pastureland in Oregon (DT50 = 75 to 81 days) (SEIS, Vol. 5, Sect. 3, Table 3.4).

When the break-down products TCP and TMP were measured in the field, it is clear that TMP is not persistent and never exceeds 0.06 ppm in any soil profile on bare ground and pastureland soil. Concentrations of TCP have been observed at 0.1 to ~0.2 ppm or higher for three-quarters of a year or longer after application of triclopyr to pasturelands.

Persistence in rice paddy soils at various depths

In the laboratory, rice paddy soils yielded half-lives that varied considerably. Rates of degradation on surface soils (DT50 = 9 to 307 days) was much greater than on soils taken from depths of about one foot (DT50 = 35 to 314 days). This phenomenon was attributed to the fact that surface soils when compared to subsurface soils had higher pH, higher organic matter content, higher microbial numbers, and the presence of acclimated versus non acclimated decomposers (microbes).

3. Environmental and Human Health Impacts

Air

Triclopyr products have very little tendency to affect air quality or cause crop damage because of low vapor pressure. (The vapor pressure of commercial products of triclopyr is 1.26×10^{-6} mm/Hg at 25° C for the active ingredient triclopyr).

Typically, the mode of application is **subsurface injection** for liquid formulations, making drift outside the treatment area unlikely.

For those cases where a **boom sprayer** applies a liquid formulation, as much as one percent of the application may drift out of the treatment area. It has been estimated for general herbicides that this amount of drift could have an impact if 120 swaths were applied and one percent of the applied pesticide drifted out of the treatment area on each pass. In this case, dosage levels higher than that intended for the target could accumulate downwind of the treatment area. This could cause an effect on non-target plants that may damage habitat and decrease the amount of forage available for waterfowl and fish in non-target areas (Forsythe et al, 1997).

For **aerial application**, as much as 17 percent of the treatment would not strike the target area. In this case, drift out of the treatment area could impinge on non-target organisms at a great distance from the site of application. Depending on how much triclopyr was deposited per unit area outside the site, there could be a significant impact on non-target wild plants or crops. In addition to effects on plants, non-target sensitive terrestrial wildlife may be adversely impacted.

Odor is unlikely to be noticed except for short periods of time following application. Since there would rarely be more than one or two applications of triclopyr per water body per year in the state of Washington, any adverse impact on quality of life due to problems with odor from triclopyr applications should be weighed carefully with the impact due to the effects of poor navigability, and effects on the recreational use of the water body.

Direct effects from breathing the vapor are unlikely for the general public since the acute LC_{50} for triclopyr TEA is greater than 2.6 mg/L (EPA RED, 1998). However, EPA has determined that there are potential exposures to persons involved in mixing, loading or entering treated sites after application is complete.

Release of Toxic Materials – Inhalation The Washington State Department of Health conducts a Pesticide Surveillance Program and has documentation of seven human exposure cases, possibly related to terrestrial use, involving skin and upper respiratory tract irritation following direct exposure to triclopyr spray mist. No signs and symptoms of systemic poisoning were reported, however some of the individuals experienced temporary irritation of the skin and upper respiratory tract. It should be noted that application of the triclopyr product Renovate® Aquatic Herbicide is directly injected under the water and not applied by aerial or spray application (WDOH, 1999).

Permit Mitigations

Drift

Follow label instructions.

Aerial applications

- Aerial applications are not permitted in Washington State waters.

Odor

No odor problems were cited in the literature.

Inhalation

Follow label instructions.

Earth

Soils

The presence of triclopyr in soil is not anticipated from aquatic treatment unless flooding occurs or the water is used for irrigation.

Flooding

If a flooding incident occurs within 120 days of application, there is a potential for triclopyr to damage upland sensitive species, particularly grapes, tobacco, vegetable crops and flowers. However, the expected half-life on soils is fairly low (8 to 18 days in the laboratory and two weeks in the field). Therefore, any adverse impact due to a flooding incident is likely to be quite limited.

Sediment

In typical situations where water is fairly shallow (0.3 to less than two meters), triclopyr in sediment has observed half-lives that range from less than one day at Lake Seminole to 5.8 days in Lake Minnetonka.

Due to the low distribution coefficient for triclopyr (0.165 to 0.925 mL/g), it does not bind tightly to sediment and therefore concentrations in sediment should remain low. This assumption is confirmed by results from field studies. For example, at Lake Minnetonka, concentrations of triclopyr in sediment were never higher than 0.334 ppm a.e. and dissipation to concentrations of ≤0.15 ppm was seen within 14 days after application. At Lake Seminole, triclopyr was not seen at significant concentrations (<0.1 ppm a.e.) except for the day of application where concentrations as high as 0.64 ppm a.e. were detected. Even in the pond studies, the concentration of triclopyr in sediment was very low and did not exceed 0.86 ppm a.e. during the first few days and dissipated to below the limit of quantification within four weeks.

These low levels of triclopyr in sediment indicate that the sediment quality should remain high in treated water bodies and that such sediments should pose little or no threat to benthic in-fauna.

Metabolites

The toxic metabolite TCP is found at even lower concentrations than triclopyr. Both laboratory and field studies indicate the concentrations of TCP in the sediment are very low and generally do not exceed 0.16 ppm and are typically less than 0.05 ppm in lakes and ponds. TCP generally dissipates to below the level of quantification within a few days of application to lakes but may take up to six weeks to dissipate entirely from ponds.

Another metabolite (TMP) is rarely detected in lake or pond sediment and is normally detected in the water column at concentrations that do not exceed 0.01 ppm a.e. TMP is generally considered to have no toxicological significance. Data supporting these conclusions can be found in Getsinger et al, (2000) Petty et al (1998) and Green et al (1989) (Table 5).

Anaerobic conditions

Triclopyr from the application of Garlon® 3A or Renovate® may have long half-lives in deep sediments under anaerobic conditions. In anaerobic conditions, triclopyr degrades to TCP with a half-life of about three and one-half years (Ladowski and Didlack (1984 in Petty et al, 1998).

Permit Mitigations

Irrigation

Follow label instructions.

Sediments

- Due to the possibility of anaerobic conditions in sediments, sediment monitoring is required prior to any third application of triclopyr on a site within a three-year period. Evidence of persistence of triclopyr or TCP in sediments is basis for denial of the third application.

Water

Surface Water

The concentrations of triclopyr in lakes that have been spot treated generally fall below the temporary drinking water residue tolerance (0.5 ppm a.e.) within one day but in rare instances can take as long as eight days. However, the concentration of triclopyr in ponds can take three to four weeks to dissipate to concentrations below 0.5 ppm a.e. (CSI, Volume 5, Sect. 3, Table 3.5, pp. 55-67).

The concentration of the toxic metabolite (TCP) has generally been low in lake and pond water with concentrations of TCP not higher than ~0.1 ppm in Lake Minnetonka, Lake Seminole, and various ponds on the day of application and generally dissipating to concentrations below the detection limit at three days after treatment.

Fish and other aquatic organisms need oxygen to survive and treatment of dense weed areas may result in dissolved oxygen decreases due to the decomposition of dead weeds. Therefore, application of triclopyr TEA products must be limited to a portion of the water body at any one time. Typically, the entire water body is not treated. Only about 20 percent of a water body is typically treated based on areas designated for priority control.

Wetlands

Because of the manner in which triclopyr products are applied, significant impact to other wetland environments is unlikely. There may be some tendency for drift into other wetland environments or a flow of water into estuarine, palustrine, riparian, lentic or lotic environments. However, it is not anticipated that the impact would be measurable due to dilution effects, as treated ponds, lakes, and canals normally flow into streams and rivers and ultimately into estuaries.

The total application of these products should not exceed 2.5 ppm a.e. for the treatment area per annual growing season. The total application of these products to control floating and emerged weeds should not exceed two gallons formulation/acre per annual growing season.

Estuarine (intertidal) Environments

Water from a stream or river containing triclopyr may flow into an estuary. However, dilution effects from the water already present in the estuary and diurnal tides should dilute triclopyr to levels where it is not significant in the water column.

Palustrine (marshy) Environments

Most immersed plants are not likely to be adversely impacted at the concentrations of triclopyr used to control fully aquatic weeds. However, floating (*Eicchornia crassipes*) and rooted submersed plants (*Myriophyllum* spp. and *Hydrocotyle* spp.), that are typically found in a palustrine environment may be affected by water that enters these areas from lakes and ponds.

It is unclear exactly how high the triclopyr concentrations must be to damage native plant species. Initial triclopyr concentrations of 2.5 ppm a.e. that remained at levels of 1.0 ppm a.e. or higher for 7 to 14 days have been known to adversely impact coontail (*Ceratophyllum* spp.), Eurasian watermilfoil (*Myriophyllum spicatum*), southern naiads (*Naja guadalupensis*), and American waterweed (*Elodea canadensis*) in water impounds (ponds) located at Elk Grove, California, Columbia, Missouri, or Lewisville, Texas (Petty et al, 1998). If these rooted macrophytes were destroyed due to herbicide applications, there would be less tendency for the marsh to flood, resulting in loss of habitat for fish, amphibians, wild birds and mammals.

Permit Mitigations

Surface water

Follow label directions.

Wetlands

- The total application should not exceed 2.5 ppm a.e. for the treatment area per annual growing season. The total application to control floating and emerged weeds should not exceed 2 gallons formulation/acre per annual growing season.

Plants

Selectivity

Triclopyr TEA controls invasive aquatic macrophytes including Eurasian watermilfoil (*Myriophyllum spicatum*), parrotfeather (*Myriophyllum aquaticum*), waterhyacinth (*Eichhornia crassipes*), alligatorweed (*Alternanthera philoxeroides*), and purple loosestrife (*Lythrum salicaria*).
Triclopyr TEA does not control desirable native species like rushes (*Juncales* spp. and *Scirpus* spp.), cattails (*Typha* spp.), duckweed (*Lemna* spp.), Flatstem pondweed (*Potamogeton zosteriformis*), Coontail (*Ceratophyllum demersum*), Southern naiad *(Najas guadalupensis*), American pondweed (*Elodea canadensis* and water paspalum (*Paspalum fluitans*), and most species of algae including the green algae (*Spirogyra* spp., *Cladophora* spp., *Mougeotia* spp. *Volvox* spp., *Closterium* spp. and *Scenedesmus* spp.), *Chara* spp. and *Anabaena* spp. (Getsinger et al, 2000; Woodburn et al, 1993; Petty et al, 1998 and Green et al, 1989, Foster et al, 1997, Woodburn, 1988 and Houtman, 1997).

Non-target Aquatic Species

Sensitive non-target aquatic species of plants are not likely to be affected at triclopyr concentrations of 2.5 ppm or less. At higher concentrations (2.5 ppm a.e.), southern naiad, American waterweed and coontail may be adversely impacted.

Algae

Sensitive non-target aquatic species of algae are not likely to be affected at triclopyr concentrations of 2.5 ppm or less.

Endangered Plant Species

Acute risk and endangered plant species levels of concern from runoff of triclopyr triethylamine salt during ground application are exceeded at ≥ 9.0 lb a.e./A (non-target plants inhabiting adjacent acreage) and ≥ 1.5 lb a.e./A (non-target plants inhabiting semi-aquatic areas) (Triclopyr RED). Aquatic use rates for this material are well below the use rates listed. Therefore, little or no harm to non-target terrestrial plants is expected due to either over-spray or the use of triethylamine salt treated irrigation water.

The total application of these products should not exceed 2.5 ppm a.e. for the treatment area per annual growing season.

Spray Drift

Spray drift has the potential to damage sensitive terrestrial plants. Species of plant that appear to be especially susceptible are grapes, tobacco, vegetable crops, and flowers or other desirable broadleaf plants. Even with low drift, onions, and sunflowers may be adversely affected by rates of application typically used to control floating and emergent weeds (6 lbs a.e/acre) or wetland non-crop weeds (9 lbs a.e./acre). For example, treatment rates as low as 0.12 to 0.005 lbs a.e./acre lbs/acre may cause 25% damage to these sensitive crop species (EPA RED, 1998) (Table 9). These rates are exceeded even when drift is low (1% to 5%). Small amounts of drift can be an issue if many swaths are applied, and particularly if the product is applied from an aircraft (Forsythe et al, 1997).

Permit Mitigations

Plants and algae

Use as directed by the label.

Endangered plant species

- The total application of these products should not exceed 2.5 ppm a.e. for the treatment area per annual growing season.

Animals

Freshwater invertebrates

Triclopyr TEA and triclopyr acid are practically non-toxic to aquatic invertebrates and are not anticipated to be an acute or chronic risk due to their fairly short half-life (typically <5 days), low intrinsic toxicity to animals, and low tendency to accumulate in animal tissue.

While formulated triclopyr is not believed to be toxic to invertebrates, higher treatment rates (2.5 ppm a.e.) present a low to moderate risk.

Observed toxicity values for *Daphnia magna* (LC50 = 376 ppm a.e.), grass shrimp (LC50 = >234 ppm a.e.), pink shrimp (LC50 = 281 ppm a.e.), fiddler crab (>314 ppm a.e.) and crayfish (LC50 >103 ppm a.e.) place triclopyr TEA in the EPA's ecotoxicology categories of slightly toxic to practically non-toxic.

Other species of invertebrates are virtually unaffected by triclopyr TEA. For example, all other species of invertebrates that were tested have an LC50 of >100 ppm a.e.

In the field where triclopyr TEA was used to control Eurasian watermilfoil, waterhyacinth, or purple loosestrife, no invertebrate mortality or changes in invertebrate population structure was seen that could be attributed to the use of triclopyr TEA (Petty et al, 1998, Green et al, 1989 and Gardner and Grue, 1996, Houtman et al, 1997, Foster et all, 1997 and Woodburn, 1988).

Amphibians

No laboratory work was conducted on the effects of triclopyr TEA against amphibians. It is anticipated that amphibians will be affected by triclopyr TEA both acutely (LC_{50} = 82 to 182 ppm a.e. = 114 to 254 ppm a.i.) and chronically (MATC = 27 to 61 ppm a.e. = 38 to 93 ppm a.i.) at concentrations similar to that affecting fish. What little data is available from the field indicates that *Rana pipiens* adults and tadpoles remain common 11 weeks after treatment of the Columbia, Missouri pond site at rates of 2.5 ppm a.e. (Petty et al, 1998).

Avian/birds

Triclopyr acid is *slightly toxic* to birds when orally dosed or consumed in the diet. The triethylamine salt is *slightly toxic to practically non-toxic* when orally dosed or consumed in the diet. Reproduction of birds may be affected at levels greater than 100 ppm (RED).

Toxicity studies indicate that triclopyr and its products used as aquatic herbicides do not pose a significant acute or chronic risk to wild birds.

Fish, free-swimming aquatic invertebrates, and benthic invertebrates

Most species of fish are tolerant of triclopyr TEA. Sensitive and environmentally relevant species such as the various salmon species (*Onchorhynchus* spp.) have demonstrated LC50s that range between 96 and 182 ppm a.e. (Wan et al, 1987). These toxicity values place triclopyr TEA in the US EPA's ecotoxicological categories of slightly toxic (LC50 = >10 to 100 ppm) to practically non-toxic (LC50 = >100 ppm).
There have been no verified cases of toxicity to fish when triclopyr is used at the maximum use rate of 2.5 ppm a.e. When mortality occurs in the field after the use of triclopyr for the control of aquatic weeds, it is usually very low ($\leq$11%) and attributable to an oxygen slump due to the presence of rapidly growing non-target aquatic plant species (Petty et al, 1998).

Triclopyr acid has been reported to be practically non-toxic to rainbow trout (LC50 = 117 ppm a.e. for rainbow trout) and bluegill sunfish (96-hour LC50 of 148 ppm a.e.) (Section 4, Tables 2, 17 and 18). Other authors have reported triclopyr acid to be moderately toxic with 96-hour LC50s ranging from 5.3 ppm a.e. for pink salmon (*Oncorhynchus gotbuscha*) to 9.6 ppm a.e. for Chinook salmon *(Oncorhynchus tshawytscha*).

Triclopyr TEA is generally safe to fish, free-swimming aquatic invertebrates, and benthic invertebrates when the EC_{50}/LC_{50} is compared to typical four-day time-weighted average expected environmental concentration (TWA- EEC). However, when the toxicity of triclopyr is compared to other pesticides, it is classified according to the U.S. EPA Ecotoxicological Categories as slightly toxic (LC_{50} = >10 to 100 ppm) to embryo/larval and juvenile eastern oyster (*Crassostrea virginica*) rainbow trout (*Onchorhynchus mykiss*), tidewater silverside (*Mendia beryllina*), chum salmon

(*Onchorhynchus keta*) and fathead minnow (*Pimephales promelas*). However, triclopyr TEA is classified as practically non-toxic (LC_{50} >100 ppm) to bluegill sunfish (*Lepomis macrochirus*), other salmon species (*Onchorhynchus* spp.), Daphnia magna, grass shrimp (*Palaemonetes pugio*), pink shrimp (*Penaeus durorarum*), fiddler crab (*Uca pugialtor*), and red swamp crayfish (*Procambarus clarki*). In general, triclopyr TEA can be considered to have very low toxicity to environmentally relevant fish and aquatic invertebrates. Triclopyr TEA appears to be extremely safe for use in the presence of threatened and endangered salmonid game-fish.

Triclopyr TEA appears to be safe for use in aquatic ecosystems. When comparing typical expected environmental concentrations (EEC) of triclopyr with laboratory LC_{50}s, the highest concentration that may be encountered immediately after application (2.5 ppm a.e. for control of submerged weeds or 4.4 ppm a.e. for control of floating and emerged weeds in shallow water) may affect more sensitive species. Fish and non-mollusk species would not be adversely impacted by these concentrations of triclopyr TEA. For example, the most sensitive fish species is rainbow trout with a 96-hour LC_{50} of 82 ppm a.e. and the most sensitive non-mollusk invertebrate is the red swamp crayfish with a 96-hour LC_{50} of >103 ppm a.e. Since these species have LC_{50}s that are >10-fold greater than the EEC that occurs immediately after application, it is not likely that they would be adversely impacted by the effects of triclopyr TEA. However, the most sensitive mollusk is the embryo larval stage of the eastern oyster with a 48-hour EC_{50} for improperly developed embryo/larvae of 22 ppm a.e. Since the risk quotient generated from this LC_{50} and the lowest initial EEC is greater than the low level of concern (0.1), this segment of the biota may be harmed by exposure to triclopyr TEA. However, since the risk quotient is not higher than the high level of concern (0.5), this segment of the biota will probably not be adversely impacted if triclopyr is classified and used as a restricted use aquatic herbicide (RQ = EEC/EC_{50} = 4.4 ppm a.e./22 ppm a.e. = 0.2). Some concern has been expressed that the eastern oyster in not an appropriate species to use in evaluations of risk for compounds that may not be used legally in estuaries. Furthermore, any concentration of triclopyr TEA entering an estuary would be greatly diluted by both untreated river/creek water and untreated sea water from the tidal action (CSI, Volume 5, Section 4, p. 63-64).

Sea water challenge tests for salmon

The following seawater challenge tests were done in support of the noxious weed control program at Ecology.

> **Effects of Three Aquatic Herbicides on Smoltification in Juvenile Pacific Coho Salmon** by King, KA[1], CE Grue[1], JM Grassley[1], CA Curran[1], WW Dickhoff[2], and JA Winton[3]
>
> Herbicides are frequently used to control exotic or nuisance aquatic plants. Utilization of herbicides in Integrated Pest Management (IPM) plans to control aquatic weeds has been hampered by court injunctions directed at the non-target toxicity of active herbicidal ingredients. Unfortunately, adequate data on the non-target toxicity of aquatic herbicides to aquatic resources are lacking, thereby

threatening the permitting process and the success of IPM strategies. Recent declines in several species/stocks of salmon and the emphasis of management and regulatory agencies to restore these populations heighten concerns. Our objective was to determine if label application rates for three commonly used aquatic herbicides impair smoltification in juvenile Pacific salmon, using coho (*Oncorhynchus kisutch*) as a model. The herbicides and water concentrations selected for study were Sonar®PR (active ingredient: fluridone; 10, 90 ppb), REWARD® (active ingredient: diquat dibromide; 0.34, 1.37 ppm), and RENOVATE® (active ingredient:triclopyr; 0.75, 2.50 ppm). Fish (mean = 22g; 20 fish/tank) were exposed to the herbicides or negative control (4 tanks/treatment) for 96 h under static conditions (11 C) and then transferred directly into flowing seawater (salinity = 27 ppt; 10 C) for 14 d. Five fish per tank were sacrificed after exposure to the chemicals, and after 1, 7 and 14 d in seawater. Endpoints were survival, body weight and fork length, muscle water content, hepatosomatic index, plasma sodium and chloride concentrations, gill ATPase, and gill histology. Tests for each herbicide were conducted concurrently. Actual concentrations were similar to nominal with the exception of fluridone (1, 10 ppb) due to a calculation error. All fish survived the chemical exposures and the first 7 d in seawater. Two fish exposed to the low concentration of REWARD died during the second week in seawater. The fish were from the same tank; no mortality was observed in other three replicate tanks. Necropsies of the two fish did not reveal any gross anomalies. Statistically significant decreases in plasma Cl concentrations were detected in fish exposed to the low and high levels of RENOVATE and REWARD while in freshwater compared to controls. Significant decreases in plasma Na and Cl were observed in REWARD-exposed fish after 24 h in seawater. Effects were short-lived and plasma ion concentrations were similar among treated and control fish after 7 and 14 d in seawater. Hepatosomatic index and muscle water content did not differ between treated fish and controls in either fresh or seawater. A few differences were detected in gill ATPase between treated and control fish, but effects were not consistent. Data on gill histology have yet to be analyzed statistically. Preliminary results suggest that, at the chemical and seawater exposures tested, the herbicides are unlikely to affect seawater adaptation in free-living juvenile Pacific salmon.

[1]Washington Cooperative Fish and Wildlife Research Unit, School of Aquatic and Fishery Sciences, Box 355202, University of Washington, Seattle, WA 98195; [2]National Marine Fisheries Service - Montlake Laboratory, Seattle, WA 98112; [3]US Geological Survey, Biological Resources Division, Western Fisheries Research Center, Seattle, WA 98115.

Mammals

There are two common routes of exposure of livestock and terrestrial wildlife to aquatic applications of Renovate®. The two routes are exposure through drinking water treated with products containing triclopyr or eating aquatic plants, fish, or other aquatic organisms from the treatment site. Based on acute and chronic studies, triclopyr and its products used as aquatic herbicides do not pose a significant acute or chronic risk to terrestrial mammals.

Threatened and Endangered Species

Minimal effects to threatened and endangered species are expected from application of aquatic herbicides containing triclopyr. Mitigation of possible effects on listed endangered species is best accomplished by following the mitigation sections for terrestrial plants, birds and animals. As stated previously, the best way to mitigate possible effects on all terrestrial species is to follow the directions listed on the label.

Other mitigation measures involve the contact of WDFW by the issuer of the permit to ascertain if any endangered species may be affected by the application of the chemical to the water body in question. Questions asked by the permit granter would ascertain if any resident endangered bird or animal species are known to use the water body in question (or its shorelines or islands) as breeding or forage areas, or if the application coincides with the migration of any endangered species. If endangered species are present, mitigation measures may involve postponing application until after the breeding season or postponement of application until after migration of the species in question. Use of an alternate means of control (i.e. mechanical) may also be an option if the risk is determined to be too great to the species in question.

Permit Mitigation

Invertebrate biota
Wetland species
Fish

Use as directed by the label.

Avian

- If the chemicals are applied according to the label, the effect on terrestrial wildlife should be minimal. Even though triclopyr products used as aquatic herbicides do not pose a significant risk to terrestrial wildlife, the following measures should be considered prior to all aquatic herbicide applications. One possible mitigation measure would be not allowing applications if large populations of birds use shorelines or islands in the water body to be treated for nesting until after nesting is complete. Another mitigation measure would be to time applications to avoid migratory waterfowl and other bird species that use certain water bodies during migration. Efforts to avoid effects on migratory and nesting birds would best be coordinated with The Washington State Department of Fish and Wildlife (WDFW).

Water, Land and Shoreline Use

Public Water Supplies - Potable Water

The Reference Dose (RfD), the amount of triclopyr residuals that could be consumed daily over a lifetime without adverse effects, was established at 0.05 mg/kg/day, based on the two-generation reproduction toxicity study in rats with a NOEL (no observed effect level) of 5.0 mg/kg/day, the lowest does tested. At the next dose level (25 mg/kg/day), an increased incidence of proximal tubular degeneration of the kidneys was observed in P1 and P2 parental rats in this study (EPA R.E.D. Facts, 1998).

Triclopyr and its toxic metabolite TCP degrade and dissipate rapidly through chemical, biological, and physical processes (Various authors in Houtman et al, 1997). Concentrations of triclopyr in sites with short half-lives will typically fall below the temporary drinking water tolerance within one to three days of application. In areas with short triclopyr half-lives, the metabolite TCP is often not detected after the day of treatment, but has been detected at concentrations of 0.05 to 0.14 ppm in Lake Seminole, Georgia (CSI, Volume 5, Sect. 3, p. 40).

Potable Water

It has also been proposed as part of the tolerance petition, that the potable water setback be 0.25 miles in order to ensure residue levels remain below 0.5 ppm (proposed allowable drinking water tolerance). This set back distance was based on the results of several field dissipation studies (Woodburn, 1988 Houtman et al, 1997, Foster et al, 1997). However, recent modeling work (Ritter and Peacock, 2000) indicates that the setback distance should vary with the concentration used and the number of acres treated. At the maximum use rate (2.5 ppm) used to treat >16 acres, the setback distance from potable water intakes should be at least 2000 feet.

Ground Water

Highly mobile and water soluble compounds are more likely to reach ground water. Triclopyr is highly mobile (Kd =0.165 to 0.975), and highly water soluble.

While triclopyr exceeds the mobility and persistence triggers used to recommend restricted use, triclopyr does not meet detection triggers for recommending restricted use due to limited monitoring data (Hoheisel et al, 1992 in EPA RED, 1998).

In one EPA study (EPA, 1992), three hundred seventy-nine wells were sampled for triclopyr, and only five detections of triclopyr residues in ground water were reported. All detections were far below levels of concern. The maximum concentration reported was 0.58 ppb.

Public water supply systems are not required to sample for triclopyr, as triclopyr is currently not regulated under the Safe Drinking Water Act (SDWA). There is no maximum contaminant level (MCL) or Drinking Water Lifetime Health Advisory (HAL) for triclopyr. However, there is a proposed MCL of 500 ppb and an estimated HAL of 350 ppb.

Due to the limited amount of data collected, it is difficult to determine if triclopyr will have an adverse impact on sensitive well recharge areas. Although EPA does not currently have surface or ground water advisories on triclopyr, surface and ground water studies may be necessary to determine the potential for triclopyr to leach under its new aquatic use labeling (EPA RED, 1998; Getsinger et al, 1997; Green et al, 1989; Getsinger et al, 2000; Petty et al, 1998 and Petty et al 1998).

Swimming

The only health concerns from triclopyr for swimming are minor eye irritation and exposure to children immediately after application. The risk of eye irritation and overexposure for children decreases rapidly because of dilution. A mandatory waiting time after application before swimming is allowed, mitigates the risk.

Exposure and risk calculations were determined for hypothetical situations involving ingestion and dermal contact with treated water while swimming and drinking potable water. Calculation of triclopyr exposures utilized the swimmer's weight, the skin surface area available for exposure, the amount of time spent in the treated water containing 2.5 and 0.5 ppm triclopyr, amount of water swallowed while swimming over specific time periods, and the estimated human skin permeability coefficient.

Risk analyses were completed for various populations. The most sensitive population was found to be children who swim for three hours and ingest water while swimming. However, a child would have to ingest 3.5 gallons of lake water where triclopyr had been recently applied to cause risk factors to be exceeded.

Based on the label use directions and the results of the triclopyr toxicology studies, the aggregate or combined daily exposure to the chemical from aquatic herbicidal weed control does not pose an adverse health concern.

The Washington State Dept. of Health has recommended a 12-hour restriction for re-entry into triclopyr treated water to assure that the eye irritation potential and any other adverse effects will not occur. WDOH also recommends that those wanting to avoid even small exposures can wait one to two weeks following application when the triclopyr residues have dissipated from the water and sediments (WDOH, 1999).

Drift

The main methods of using Renovate® and Garlon® 3A largely preclude the effects of drift. This liquid product is either injected by subsurface methods (which precludes drift) or applied as large droplets at low pressure which mitigates the effects of drift. It is also recommended that a thickening agent be used to control drift when applying liquid herbicides to the water surface or to wetland associated weeds.

The Garlon® 3A proposed label states the following: "Applications should be made only when there is little or no hazard from spray drift. Very small quantities of spray, which may not be visible, may seriously injure susceptible plants. Do not spray when wind is blowing toward susceptible crops or ornamental plants are near enough to be injured. It is suggested that a continuous smoke column at or near the spray site or a smoke generator on the spray equipment be used to detect air movement, lapse conditions, or temperature inversions (stable air). If the smoke layers or indicates a potential of hazardous spray drift, do not spray." Spray pressures should be kept low enough to provide course droplets. The spray boom should be kept as close to the ground or water surface as possible. In addition, a thickening agent or a high viscosity inverting system should be used to prevent drift.

Permit Mitigation

Water intakes and Drinking water

Follow label instructions.

Irrigation

Follow label directions

Ground Water

- Use according to label directions. Ground water or sediment monitoring is required prior to any third application of triclopyr on a previously treated site planned within a three-year period. Evidence of persistence of triclopyr or TCP in sediment or ground water is basis for denial of the third application.

Swimming

- The Washington State Dept. of Health has recommended a 12-hour restriction for re-entry into triclopyr treated water to assure that the eye irritation potential and any other adverse effects will not occur. WDOH also recommends that those wanting to avoid even small exposures can wait 1-2 weeks following application when the triclopyr residues have dissipated from the water and sediments (WDOH, 1999).

Fish Consumption

Agriculture

Irrigation

Follow label directions.

Data Gaps and Considerations

Since triclopyr bioaccumulates at low levels (~1.0 to 2.0 in crayfish and clams), further evaluation of the accumulation effects of triclopyr on clams and crayfish should be considered before establishing residue tolerance limits on these species. The current proposed residue tolerance for fish and shellfish is 0.2 ppm.

Wetland (forestry) herbicides may be of particular concern to Native Americans. Forestry products are harvested by Native Americans and are used in their diets, in the making of traditional basketry, for medicinal purposes and ceremonial activities. Work is currently being conducted to determine if these exposure scenarios may affect Native Americans in a manner not reflected in the current assessment.

No laboratory work was conducted on the effects of triclopyr TEA against amphibians. It is anticipated that amphibians will be affected by triclopyr TEA both acutely (LC_{50} = 82 to 182 ppm a.e. = 114 to 254 ppm a.i.) and chronically (MATC = 27 to 61 ppm a.e. = 38 to 93 ppm a.i.) at concentrations similar to that affecting fish. What little data is available from the field indicates that *Rana pipiens* adults and tadpoles remain common 11 weeks after treatment of the Columbia, Missouri pond site at rates of 2.5 ppm a.e. (Petty et al, 1998).

4. Mitigation Summary for Triclopyr TEA

Conditions of Treatment	**Mitigation**
Drift	Follow label directions.
Odor	Aerial applications are not allowed so this should not be an issue.
Inhalation	Persons involved with mixing or applying should follow the directions on the label for safety. Application should be by direct injection under the water and not applied by aerial or spray application.
Irrigation	Follow label directions.
Surface water/fish and other aquatic life	Follow label directions.
Wetlands, estuaries and marshes that treated water may flow into.	The total application of these products should not exceed 2.5 ppm a.e. for the treatment area per annual growing season. The total application of these products to control floating and emerged weeds should not exceed 2 gallons formulation/acre per annual growing season.
Non-target plants, including endangered plant species	The total application of these products should not exceed 2.5 ppm a.e. for the treatment area per annual growing season.
Invertebrates	If triclopyr TEA is treated as a restricted use herbicide, it should not cause adverse impact to the invertebrate biota.
Birds	Do not apply when large populations of birds use shorelines or

	islands in the water body to be treated for nesting until after nesting is complete. Avoid migratory waterfowl and other bird species that use certain water bodies during migration.
Threatened and endangered species	Mitigation of possible effects on listed endangered species is best accomplished by following the mitigation sections for terrestrial plants, birds and animals. Follow the directions listed on the label. Other mitigation measures involve the contact of WDFW by the issuer of the permit to ascertain if any endangered species may be affected by the application of the chemical to the water body in question.
Swimming	The Washington State Dept. of Health has recommended a 12-hour restriction for re-entry into triclopyr treated water to assure that the eye irritation potential and any other adverse effects will not occur. WDOH also recommends that those wanting to avoid even small exposures can wait 1-2 weeks following application when the triclopyr residues have dissipated from the water and sediments (WDOH, 1999).
Potable water	Follow label directions.
Fishing/fish consumption/shellfish consumption	Follow label directions.
Ground water	Use according to label directions. Ground water or sediment monitoring is required prior to any third application of triclopyr on a previously treated site planned within a three-year period. Evidence of persistence of triclopyr or TCP in sediment or ground water is basis for denial of the third application.

References

The primary reference for this document is the *Supplemental Environment Impact Statement Assessments of Aquatic Herbicides: Study No. 00713, Volume 5, Triclopyr*, by Compliance Services International, Tacoma, Washington, submitted to the Dept. of Ecology under a grant contract. The five sections are as follows:

Section 1 – Label Description & History, 65 pp.
Section 2 – Chemical Characteristics, 10 pp.
Section 3 – Environmental Fate, 94 pp.
Section 4 – Environmental Effects, 160 pp.
Section 5 – Human Health Effects, 47 pp.

The following are references cited in the above document:

Section 1 – Label Description & History

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