



# **Environmental Impact Statement for Penoxsulam, Imazamox, Bispyribac-sodium, Flumioxazin, & Carfentrazone- ethyl**

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## **Addendum to the Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management**

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Cover Photo: Fragrant water lily, a state-listed noxious weed.

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## **Addendum to the Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management**

*by;*

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- The Washington State Department of Agriculture toxicologist Dr. Jim Cowles for reviewing the EIS.

# Fact Sheet

**Project Title:** Draft Environmental Impact Statement for penoxsulam, imazamox, bispyribac-sodium, flumioxazin, and carfentrazone-ethyl. Addendum to the *Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management* for the Washington State Department of Ecology (Ecology) Aquatic Plant Management Program.

**Project Description:** The proposed action is the review of five active herbicidal ingredients for inclusion into Ecology's aquatic pesticides permits. The active ingredients are:

- Penoxsulam
- Imazamox
- Bispyribac-sodium
- Flumioxazin
- Carfentrazone-ethyl

The is a non-project proposal under the State Environmental Policy Act (SEPA) rules such that the Environmental Impact Statement (EIS) will be integrated with on-going agency planning and permitting processes for aquatic herbicides. Ecology's Water Quality Program completed a Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management in February 2001 (Publication No. 00-10-040). The current evaluation for penoxsulam, imazamox, bispyribac-sodium, flumioxazin, and carfentrazone-ethyl is an addendum to that EIS.

The recommended alternative is an integrated aquatic plant management approach that uses the most effective and appropriate mix of vegetation control methods. These may include biological, manual, mechanical, chemical methods, and taking no action.

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**Licenses, Permits:** This list reflects state and local permits and licenses that may be required for the chemical control of freshwater plants and algae. Requirements may change; check with state resource agencies and local and federal governments to determine permit requirements for a particular project.

Ecology: Coverage under NPDES/State waste discharge permits

Washington State Department of Agriculture: Applicator’s license for aquatic application of registered pesticides

Local Governments: Substantial Development Permit (Shorelines Management Act) in certain locales

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# Executive Summary

Aquatic plants are a valuable component of aquatic ecosystems that in most situations require protection. They provide cover, habitat, and food for many species of aquatic biota, fish, and wildlife. However, they can also limit certain water body 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. Noxious weed species like purple loosestrife impair critical wetlands. Consequently, Ecology's Water Quality Program receives requests for permits from various businesses and entities to use herbicides and other control methods to manage excessive native and noxious aquatic plant species in various water bodies and wetlands. 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 chemical methods may have significant adverse environmental impacts, and that an Environmental Impact Statement was necessary.

A Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management was completed by Ecology's Water Quality Program in February 2001 (Publication No. 00-10-040). The current evaluation for new active ingredients - penoxsulam, imazamox, bispyribac-sodium, flumioxazin, and carfentrazone-ethyl is a supplement to that Environmental Impact Statement. It is an addendum to the Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management published February 2001, Publication Number 00-10-040 ([www.ecy.wa.gov/pubs/0010040.pdf](http://www.ecy.wa.gov/pubs/0010040.pdf)). The Final Supplemental Environmental Impact Statement is a supplement to the Washington State Department of Ecology's (Ecology) 1980 EIS for aquatic plant management, which addressed the application of aquatic herbicides to freshwater.

Ecology currently does not have resources to develop independent risk assessments for new active ingredients for aquatic use in Washington. Therefore, it intends to rely on the Environmental Protection Agency (EPA) risk assessment evaluations of new aquatic pesticide products and any other risk assessments (e.g., Canadian, European, New York State, etc.) and information sources that may be available for these active ingredients when writing this SEIS. Ecology provides references used to evaluate each active ingredient at the end of each section. Because Ecology relies on EPA risk assessments in the SEIS, it provides a short description of EPA's pesticide laws and the EPA process for evaluating new active ingredients in this document.

The preferred alternative is an integrated approach that uses the most effective and environmentally protective mix of management methods and includes adaptive management elements. Control methods may include biological, physical, mechanical, and chemical control technologies. Other alternatives analyzed include chemical use only, physical/mechanical use only, biological use only, and taking no action.

# The Preferred Alternative – An Integrated Aquatic Vegetation Management Plan

See the language for the preferred alternative for aquatic plant management in Ecology's *Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management* (2001) and Ecology's *Environmental Impact Statement for Permitted Use of Triclopyr* (2004), incorporated by reference into this document.

- *Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management* [www.ecy.wa.gov/biblio/0010040.html](http://www.ecy.wa.gov/biblio/0010040.html)
- *Environmental Impact Statement for Permitted Use of Triclopyr* [www.ecy.wa.gov/biblio/0410018.html](http://www.ecy.wa.gov/biblio/0410018.html)

## The No Action Alternative

See the language for the no action alternative for aquatic plant management in Ecology's *Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management* (2001) and Ecology's *Environmental Impact Statement for Permitted Use of Triclopyr* (2004).

## Mechanical and Manual Methods as an Alternative

See the language for the mechanical and manual alternatives for aquatic plant management in Ecology's *Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management* (2001) and Ecology's *Environmental Impact Statement for Permitted Use of Triclopyr* (2004).

## Biological Methods as an Alternative

See the language for biological alternatives for aquatic plant management in Ecology's *Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management* (2001) and Ecology's *Environmental Impact Statement for Permitted Use of Triclopyr* (2004).

# Chemical Methods as an Alternative

## Introduction to chemical control methods

This section updates the “Use of Chemicals Only” sections of the 1980 Aquatic Plant Management Environmental Impact Statement and its 2001 Supplement and adds new data on active ingredients - penoxsulam, imazamox, bispyribac-sodium, flumioxazin, and carfentrazone-ethyl. The information on each herbicide reviewed in this section is brief, concise, and not overly technical. Ecology based its analysis and evaluation of the herbicides primarily on EPA risk assessments supporting the registration of each product. Ecology references the documents used in its evaluation at the end of each herbicide section. Due to lack of funding and staff resources, Ecology does not plan to conduct independent risk assessments for these chemicals.

For information about other aquatic herbicides, see also the chemical control method sections for aquatic plant management in Ecology’s *Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management* (2001), Ecology’s *Final Supplemental Environmental Impact Statement for Diquat* (2002), and Ecology’s *Environmental Impact Statement for Permitted Use of Triclopyr* (2004). These documents evaluate 2,4-D, copper compounds, diquat, endothall, fluridone, glyphosate, and triclopyr. See the Washington State Department of Agriculture’s *Human Health and Ecological Effects Risk Assessment for Imazapyr* (2009) for information about imazapyr.

### Types of herbicides

Lake managers select herbicides based on effectiveness, impacts, cost, and suitability for the waterbody and targeted plant species. The effectiveness of an aquatic herbicide depends on its mode of action, suitability for the targeted plant species, its concentration and contact time requirements, and many other site-specific environmental factors. Herbicides used for aquatic plant management fall into general categories:

- Contact herbicides destroy only the parts of the plant exposed to the chemical (usually foliage). Plants generally grow back from roots after treatment with contact herbicides. Treatment with a contact herbicide typically causes treated vegetation to drop rapidly from the water column to the sediment where it decomposes.
- Plants translocate systemic herbicides throughout the foliage and roots of the plant and these herbicides often kill the entire plant. Systemic herbicides are generally much slower acting than contact herbicides and it may take several weeks to months for plants to drop from the water column.
- Broad-spectrum herbicides kill or affect most, if not all plants, when used at an appropriate concentration and contact time.

- Selective herbicides affect only certain species (typically dicots or broad-leaf monocots). Sometimes applicators can use broad-spectrum herbicides selectively (e.g., low concentrations when the target plant is susceptible).

## Information about aquatic plants

Scientists characterize aquatic plants as submersed, emergent, floating-leaved, or floating, depending on the growth habit of the species. Plants growing below the water surface are submersed plants and these plants may only partially emerge above the water when flowering. An example of a submersed plant is Eurasian watermilfoil (*Myriophyllum spicatum*). Plants growing from below the water to above the water line are emergent and are typically found in shallow water along the shoreline or in wetland areas. An example of an emergent plant is purple loosestrife (*Lythrum salicaria*). Plants growing on the surface of the water and rooted in the sediment are floating leaved plants. An example of a floating leaved plant is the fragrant water lily (*Nymphaea odorata*). Plants generally with dangling roots growing in or on the water's surface are floating plants. An example of a floating plant is duckweed (*Lemna* spp.). For information about identification of Washington's freshwater plants, see [www.ecy.wa.gov/programs/wq/plants/plantid2/index.html](http://www.ecy.wa.gov/programs/wq/plants/plantid2/index.html).

## Pesticide registration requirements

### Environmental Protection Agency statutory requirements

The Environmental Protection Agency (EPA) regulates pesticides under four major statutes:

1. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)
  2. The Federal Food, Drug, and Cosmetic Act (FFDCA).
  3. The Food Quality Protection Act (FQFA).
  4. The Clean Water Act (CWA).
- FIFRA requires that pesticides be registered by EPA before they may be sold or distributed for use in the United States and that they perform their intended functions without causing unreasonable adverse effects on people or the environment when used according to EPA-approved label direction ([www.epa.gov/pesticides/regulating/laws/fqpa/fqpareport.pdf](http://www.epa.gov/pesticides/regulating/laws/fqpa/fqpareport.pdf)).
  - The FFDCA authorizes EPA to set tolerances, or maximum legal limits, for pesticide residues in food. Tolerance requirements apply equally to domestically produced and imported food.
  - The FQFA fundamentally changed the way that EPA regulates pesticides. Some of the major requirements include stricter safety standards, especially for infants and children, and a complete reassessment of all existing pesticide tolerances.
  - A 2011 court ruling directed EPA to require National Pollutant Discharge Elimination System (NPDES) permits for aquatic pesticide applications under the CWA. EPA will issue its general permit by October 31, 2011.

EPA requires extensive data as part of its registration review and approval process, requiring more than 120 studies before granting a registration for most pesticides used in food production (The aquatic herbicides evaluated in this SEIS are all used in food production). EPA tiers these study requirements to the intended use and certain properties of the pesticide. The studies allow EPA to assess risks to human health, domestic animals, wildlife, plants, surface and groundwater, beneficial insects, and other environmental effects. When new evidence arises to challenge the safety of a registered pesticide, EPA may take action to suspend or cancel its registration and revoke the associated tolerances.

Although the active ingredients evaluated in the SEIS addendum are for management of freshwater plants and/or algae, all of these aquatic-registered active ingredients also have uses for weed management in crops and are therefore subject to the FFDCA. This ensures an additional level of scrutiny to these aquatic-registered active ingredients.

### **EPA pesticide registration process**

Before the EPA registers pesticides, they must undergo laboratory testing for short-term (acute) and long-term (chronic) health effects. Researchers feed or administer doses to laboratory animals that are high enough to cause toxic effects. These tests help EPA scientists determine how a chemical might affect humans, domestic animals, aquatic animals, and wildlife. Pesticide products used according to label directions are unlikely to cause toxic effects to non-target organisms. The label ensures that the amount of pesticide that people, pets, and wildlife may be exposed to is low compared to the doses administered to laboratory animals.

### *EPA ecological risk assessments*

EPA conducts an ecological risk assessment (Environmental Fate and Ecological Risk Assessment - EFED) for each active ingredient during the pesticide registration process. Ecology reviewed the EFED risk assessments for each of the active ingredients when developing the SEIS addendum. EPA used the most sensitive toxicity endpoints from surrogate test species to estimate treatment-related direct effects on acute mortality and chronic reproductive, growth, and survival endpoints.

The registrant conducts toxicity tests to determine effects of pesticide exposure on birds, mammals, fish, terrestrial and aquatic invertebrates, and plants. These tests include short-term acute, sub-acute, and reproduction studies and are typically arranged in a hierarchical or tiered system that progresses from basic laboratory tests to applied field studies. EPA uses a few surrogate species to represent fish, birds, and mammals and does not require testing for reptiles and amphibians. EPA assumes that conclusions drawn from avian toxicity studies are applicable to reptiles and studies with fish are applicable to amphibians. EPA uses these toxicity studies to:

- Evaluate the potential of a pesticide to cause adverse effects.
- Determine whether to require further testing.

- Determine the need for precautionary label statements that minimize any potential adverse effects to non-target animals and plants.

In general, categories of acute toxicity ranging from "practically nontoxic" to "very highly toxic" have been established for aquatic organisms based on lethal concentration (LC<sub>50</sub>) values, terrestrial mammals based on lethal dose (LD<sub>50</sub>) values, avian species based on LC<sub>50</sub> values, and non-target insects based on LD<sub>50</sub> values for honey bees. See appendix B for a table of EPA's ecotoxicological categories for mammals, birds, and aquatic organisms.

*EPA human health risk assessments and the law*

Federal law requires detailed evaluation of pesticides to protect human health ([www.epa.gov/pesticides/factsheets/riskassess.htm](http://www.epa.gov/pesticides/factsheets/riskassess.htm)). In 1996, Congress made changes to strengthen pesticide laws through the FQPA. FQPA required that EPA consider:

- *A new safety standard:* FQPA strengthened the safety standard that pesticides must meet before EPA approves their use. EPA must ensure with a reasonable certainty that no harm will result from the legal uses of the pesticide.
- *Exposure from all sources:* In evaluating a pesticide, EPA must estimate the combined risk from that pesticide from all non-occupational sources such as:
  - Food sources
  - Drinking water sources
  - Residential sources
- *Cumulative risk:* EPA is required to evaluate pesticides in light of similar toxic effects that different pesticides may share, or a "common mechanism of toxicity." EPA is developing a methodology for this type of assessment.
- *Special sensitivity of children to pesticides:* EPA must ascertain whether there is an increased susceptibility from exposure to the pesticide to infants and children. EPA must build in an additional 10-fold safety factor into their risk assessment to ensure the protection of infants and children, unless it is determined that a lesser margin of safety will be safe for infants and children. The use of the extra 10-fold safety factor for children is in addition to the traditional 100-fold safety factor. To further increase protections for infants and children, EPA now requires registrants to conduct acute, subchronic, and developmental neurotoxicity studies. EPA also updated the set of test guidelines for development of data on reproductive and developmental effects.

The FQPA requires the EPA to set tolerances or grant exemptions for all the ingredients in a pesticide product that is used on food. A tolerance is the maximum amount of pesticide chemical residue that can be in or on a food or feed commodity. EPA must determine that the levels of the chemical proposed in the tolerance are "safe". Safe means a reasonable certainty of no harm to human health. An exemption from a tolerance is issued when EPA determines that the total

quantity of the pesticide chemical in or on the food will present no hazard to public health. Generally, other ingredients in pesticide formulations are not pesticidally active themselves and are exempt from the need for a tolerance so long as they do not present a hazard to public health.

#### *Reduced risk herbicides*

The EPA Office of Pesticide Program's Conventional Reduced Risk Program expedites the review and regulatory decision-making process of conventional pesticides that pose less risk to human health and the environment than existing conventional alternatives. Reduced risk pesticides typically have one or more of the following advantages over existing conventional pesticides and these include:

- Low impact on human health.
  - Very low mammalian toxicity.
  - Toxicity generally lower than currently-registered higher risk conventional pesticides.
  - Can displace chemicals that pose potential human health concerns.
  - Reduce exposure to pesticide handlers and post application exposure.
  
- Lower toxicity to non-target organisms (birds, fish, plants).
  - Very low toxicity to birds, honeybees, fish.
  - If toxicity is similar to conventional herbicides, than lower exposure potential.
  - Potential toxicity/risk is capable of mitigation.
  
- Low potential for groundwater contamination.
- Lower use rates or fewer applications than conventional pesticides.
- Low pest resistance potential (For example, reduced risk pesticides may have a new mode of action).
- Compatibility with integrated pest management (IPM) practices.

The reduced risk designation applies to only certain uses of a particular pesticide and may not include all labeled uses for that product.

#### *Conditional registrations*

The following information is from the Pesticide Regulation Desk book by the Environmental Law Institute. “*When EPA does not have enough data to make an unconditional registration decision under FIFRA, EPA may conditionally register a pesticide under FIFRA. Currently most new pesticide registrations are conditional. To qualify for conditional registration, EPA must find that (1) the data are lacking because insufficient time has elapsed since EPA imposed the data requirement, (2) the use of the pesticide during the conditional period will not cause unreasonable environmental harm, and (3) the use of the pesticide is in the public interest.*” The Handbook noted that most registrations for new active ingredients are conditional registrations.

## Washington state aquatic pesticide oversight

The Washington State Department of Agriculture (WSDA) classifies all aquatic herbicides as restricted use. Only trained and certified applicators or people under their direct supervision can legally purchase and apply aquatic herbicides in Washington. Most aquatic pesticide treatments occur under joint NPDES and State Waste Discharge permits administered by Ecology. Ecology allows some *de minimus* treatments to occur outside of the NPDES permitting process, but under state law, applicators must be licensed for all aquatic pesticide treatments.

### Tank mixes and adjuvants

*Tank mixes:* There have been changes in the way the Ecology regulates adjuvants and tank mixes since the last EIS updates. Ecology does not prohibit tank mixes if the product label allows tank mixes and the applicator uses active ingredients and adjuvants allowed in the appropriate NPDES permit. Scientists find that combining low levels of two active ingredients may achieve effective management of invasive plants, lessening the need for retreatment, and minimizing impacts to non-target species. Often, the amount of combined ingredients results in less overall chemical applied to the environment and less damage to non-target plants.

*Adjuvants:* Ecology includes a list of WSDA approved adjuvants in its NPDES permits. WSDA registers spray adjuvants for aquatic use if the registrant can demonstrate that the proposed use will not adversely affect desirable aquatic species. WSDA requires data on aquatic acute toxicity of the adjuvant to fish and aquatic invertebrates (WAC 16-228-1400(3) (e)). WSDA has criteria to register an adjuvant for aquatic use in Washington. These are:

- The adjuvant must fulfill all requirements for registration of a food /feed use spray adjuvant in Washington.
- The adjuvant must be either slightly toxic or practically non-toxic to freshwater fish. Rainbow trout (*Oncorhynchus mykiss*) is the preferred test species.
- The adjuvant must be moderately toxic, slightly toxic, or practically non-toxic to aquatic invertebrates. Either *Daphnia magna* or *Daphnia pulex* are acceptable test species.
- The adjuvant formulation must contain less than 10% alkylphenol ethoxylates (including alkylphenol ethoxylate phosphate esters). This criterion is due to their potential for adverse effects to aquatic invertebrates, fish, and oysters (based on research conducted at Washington State University and the University of Washington).
- The adjuvant formulation must not contain any alkyl amine ethoxylates (including tallow amine ethoxylates). This criterion is due to their potential for adverse effects to amphibians (based on research conducted at the University of Pittsburgh).

*Exceptions:* WSDA may register spray adjuvants for aquatic use that do not meet one or more of the above criteria if the registrant:

- Provides data which demonstrates that the proposed use will not adversely affect desirable aquatic species, or
- Limits aquatic use to non-fish bearing waters only.

These criteria do not apply to adjuvants WSDA permitted for use under an experimental use permit.

WSDA requires using *EPA Ecological Effects Test Guidelines* for fish acute toxicity testing (OPPTS 850.1075) and aquatic invertebrate acute toxicity testing (OPPTS 850.1010). WSDA prefers Good Laboratory Practice studies, but does not require them. A range of concentrations (five or more) should be tested to accurately calculate the dose–response curve and the LC<sub>50</sub> for fish or Effective Concentration (EC<sub>50</sub>) for aquatic invertebrates. WSDA may waive the requirement for definitive testing if the range-finding test indicates that the LC<sub>50</sub> or EC<sub>50</sub> is greater than 100 mg/L.

WSDA reviews the studies to see if they are consistent with EPA test guidelines, and will recommend whether the studies are acceptable to WSDA. If the studies are acceptable and the adjuvant meets WSDA criteria for registration for aquatic use, then WSDA will register the adjuvant for aquatic use and request that Ecology add the adjuvant to the permits for aquatic plant control.

## **Permits for aquatic herbicides/algaecides**

Since 2002, Ecology has regulated herbicide application under general NPDES/State Waste Discharge permits instead of site-specific administrative orders. The two principal permits that allow herbicide use in and along lakes, rivers, and wetlands are the Aquatic Plant and Algae Management General Permit and the Aquatic Noxious Weed Management General Permit. The special condition section of these general permits contains mitigations for herbicide use. Mitigations can include residential and business notifications, priority species timing windows, preparation of management plans called Discharge Management Plans, limiting the amount of littoral zone treated for nuisance plant projects, and many other special provisions to help protect the environment.

## **Evaluation of five active ingredients**

In this SEIS addendum, Ecology will evaluate five EPA-registered active ingredients for addition to Ecology's aquatic pesticide NPDES/State Waste Discharge permits. The active ingredients are penoxsulam, imazamox, bispyribac-sodium, flumioxazin, and carfentrazone-ethyl. The

evaluation includes a summary of the registration status, potential environmental effects, potential human health impacts, and recommended mitigations to minimize the effects of chemical application. This information closely follows the SEPA checklist and previous Ecology EIS.

All these aquatic herbicides are EPA reduced risk pesticides. Because all have crop uses and were registered after 1996 when the FQPA required more rigorous effectiveness evaluation, they have established food tolerances. Penoxsulam, imazamox, bispyribac-sodium are systemic herbicides that work by inhibiting a biochemical pathway specific to plants. Flumioxazin and carfentrazone-ethyl are contact herbicides. Because of their recent aquatic registration status, there is currently little information available in the peer-reviewed literature about their effects or uses. This is in contrast to some of the herbicides registered nearly 60 years ago (and still being used) with thousands of references.

Although Ecology uses chemical trade names in the SEIS addendum. Ecology does not endorse any product or manufacturer. Currently for each active ingredient, there is only one formulation registered for aquatic use. This may change as patent holders' license other companies or develop other products that use the active ingredient for aquatic use or as these active ingredients come off patent and other entities produce generic versions. This SEIS addendum does not limit the use of the active ingredient to only one product or manufacturer.

## Evaluation of penoxsulam

*Penoxsulam*: 2-(2,2-difluoroethoxy)--6-(trifluoromethyl-N-(5,8-dimethoxy[1,2,4] triazolo[1,5-c]pyrimidin-2-yl)) benzenesulfonamide. Penoxsulam is a triazolopyrimidine herbicide.

### 1. Registration status

EPA conditionally registered penoxsulam in 2004 for use in rice fields to control broadleaf weeds. EPA has since registered penoxsulam to manage aquatic plants (in-water treatments, foliar applications, and dewatered sediment treatments) and broadleaf weeds in turf (typically golf courses). An aquatic formulation sold as Galleon SC by SePRO Corporation received Section 3 federal registration for aquatic use in 2007. WSDA has registered penoxsulam in Washington for aquatic. Penoxsulam is an EPA reduced risk pesticide.

### 2. Description

Penoxsulam is the active ingredient in broad spectrum, systemic herbicide products used for both terrestrial and aquatic application sites. Penoxsulam is an acetolactate synthase (ALS) inhibitor herbicide. ALS is a plant enzyme that regulates the production of essential amino acids in plants (valine, leucine, and isoleucine). ALS is the first enzyme in the biosynthetic pathway for these amino acids. Inhibitors of ALS slowly starve plants of these amino acids

and kill the plant by halting DNA synthesis. Animals do not use these same biochemical pathways as plants.

Penoxsulam is absorbed via leaves, shoots, and roots, and translocated to meristematic tissues. Penoxsulam treatment causes cessation of cell division and subsequent growth in plants. Penoxsulam affects new plant growth more rapidly than older plant tissue.

Penoxsulam is considered a slow acting herbicide because it can require 60 to 120 days for a complete kill of the targeted plants with its effectiveness highly dependent on contact times and growing conditions. Cool weather or other conditions that affect plant growth can delay the herbicide response if the plants have reduced growth rates.

Herbicide symptoms include immediate growth inhibition, a chlorotic growing point with some tissue reddening, necrosis of the terminal bud after two or more weeks of exposure, and slow plant death over a period of 60-120 days or longer. Penoxsulam is generally very effective for the control of broadleaf plants (dicots and broadleaf monocots) and sedges. It therefore exhibits some selectivity. Managers can use penoxsulam as both a pre-and a post-emergent herbicide.

*Typical aquatic use:* Applicators may use penoxsulam for the management of freshwater aquatic vegetation in ponds, lakes, reservoirs, wetlands, drainage ditches, non-irrigation canals, and other quiescent bodies of water and along shorelines and in riparian areas for the control of floating, submersed, and emergent plant species. Applicators may spray aquatic formulations of penoxsulam onto emergent plants, apply penoxsulam directly into water, or apply to dewatered plants/sediment.

Applicators must use a surfactant for effective emergent and floating-leaved plant treatments (Ecology lists adjuvants approved for aquatic use in its water quality permits). For foliar applications, the rate is 2-5.6 fluid ounces per acre. For in-water treatments, applicators may need to apply split or multiple applications to maintain herbicide concentrations in the water at sufficient levels for optimum control. Typical application rates of penoxsulam are 10-20 ppb water column concentrations in an initial treatment with additional “bump” applications of 5-10 ppb to keep the water concentrations at 5-10 ppb for 45 to 90 days. This treatment scenario is similar to the way that applicators currently apply fluridone products for Brazilian elodea (*Egeria densa*) or Eurasian watermilfoil (*Myriophyllum spicatum*) management. According to the EPA label, the in-water concentration of any single application or sum of all applications must not exceed 150 ppb per annual growth cycle.

There are no drinking water restrictions for humans, livestock, pets, or other animals and no swimming or fishing/fish consumption restrictions for penoxsulam. There are irrigation restrictions except when irrigating turf.

There are 11 major degradation products identified for penoxsulam, with six considered as being of toxicological concern. However, none of the metabolites or degradates have been identified as having a higher potential toxicity than the parent compound (penoxsulam). The EPA used the acute penoxsulam concentration as the chronic concentration for their risk quotient determination. This approach ensured that the risk assessment addressed the potential threat posed by the degradates as long as they are not significantly more toxic or persistent than the parent. The registrant submitted several studies on the acute toxicity of the penoxsulam degradates to *Daphnia magna*. Their 48-hour EC<sub>50</sub> values ranged from >1.0 ppm to >100 ppm. EPA concluded that the penoxsulam degradates were not as toxic as the parent compound.

During a previous assessment for the use of penoxsulam on rice, EPA thought that some of the degradation products might pose additional phytotoxicity concerns. To reduce this uncertainty, EPA required additional testing on vegetative vigor and seedling emergence for the major degradates. This testing determined that none of the eleven metabolites caused any observable injury to pre-emergent seeds, while only two of the eleven caused noticeable injury to seedlings (and only at the highest levels). In light of these results, EPA chose to require no further testing of degradates for phytotoxicity.

### **3. Environmental and human health impacts**

This section describes anticipated impacts of using penoxsulam herbicide to control freshwater aquatic plants on the environment, aquatic biota, and human health. Ecology recommends mitigation measures, when appropriate. Applicators may use penoxsulam at concentrations no greater than the maximum-labeled rate per growing season in lakes, ponds, and reservoirs. This concentration poses negligible risk to the environment and non-target species based upon testing conducted under EPA guidelines and evaluated under EPA risk assessments.

#### **Earth**

##### *Soils*

In terrestrial environments, penoxsulam dissipates through soil photolysis (chemical breakdown due to sunlight) and biotic degradation (breakdown due to microbial action). When tested across a range of agricultural soils, penoxsulam has Koc values ranging from 12 to 253 L/kg indicating that penoxsulam is weakly adsorbed to soil with moderate mobility in the soil profile (Koc values greater than 1000 indicate that a pesticide is very strongly attached to soil and less likely to move unless soil erosion occurs). Fine-textured soils and those high in organic content will bind penoxsulam more tightly than coarse/medium soils low in organic matter. EPA concluded that penoxsulam is expected to be very mobile in soil, but not very persistent, in either aqueous or terrestrial environments.

Researchers tested the effects of penoxsulam on soil respiration and nitrogen transformation (after terrestrial use in rice fields). They did not observe deviations greater than 25% in the treated plots compared to the control after 28 days at 12.4 times the field application rate. Reviewers concluded that effects on soil microorganisms from penoxsulam use in rice fields are negligible.

In general, Ecology does not expect impacts to soils from the application of penoxsulam products to manage aquatic plants in water bodies or along shorelines in Washington State because there will be minimal exposure. Ecology does not anticipate significant drift onto soils through application to submersed, floating, or emergent plants. Applicators usually apply liquid formulations through subsurface hoses for submersed plant treatment. Information on the label, such as controlling droplet size, helps applicators control off-target drift when treating emergent or floating leaved vegetation using application equipment such as hoses or backpack sprayers. Applications of granular formulations (should a granular penoxsulam product become available) will typically be made from hand-held spreaders, spreaders mounted on boats, or subsurface delivery systems.

Applicators must follow all mixing and loading procedures found on herbicide labels to prevent spills on unprotected soil. In the event of a spill, applicators must follow spill response procedures outlined in Ecology's water quality permit. Ecology recommends no mitigation except for label requirements.

#### *Sediment*

Penoxsulam dissipates in clear and shallow water under favorable light conditions, through direct aqueous photolysis ( $t_{1/2} = 1.5-14$  days). Penoxsulam is slightly more persistent in aerobic aquatic environments ( $t_{1/2} = 12-38$  days) and anaerobic environments ( $t_{1/2} = 5-11$  days). Penoxsulam does not bind tightly to sediment. Researchers conducted penoxsulam dissipation studies in ponds with various types of sediments (silt-loam, silt-clay, etc.) and different locations (Arkansas, Italy, France, Japan,). EPA determined that the total system half-life for penoxsulam using linear regression of log-transformed data was 16 to 38 days. EPA concluded that although penoxsulam is not expected to be persistent, its rate of degradation in aquatic environments is highly dependent on the ability of sunlight to penetrate water at treatment sites. In clear, shallow waters, photolysis is the principle degradation pathway. In weed-choked, shaded, or turbid waters, the slower process of aerobic degradation determines penoxsulam dissipation.

#### **Air**

Ecology expects minimal impacts to air quality. Any impacts would be associated with the insignificant amount of exhaust emissions related to the use of application equipment. There should be little to no inhalation exposure to the applicator or to bystanders due to application methods and the chemical properties of penoxsulam. Penoxsulam has an extremely low

vapor pressure ( $9.55 \times 10^{-14}$  Pa at 25° C) and that together with low Henry's law constant ( $2.95 \times 10^{-14}$  Pa m<sup>3</sup> mol<sup>-1</sup>) indicates that it will not dissipate by volatilization. Losses from leaf surfaces (from emergent plant or floating plant spraying) by volatilization following application are not likely and considered insignificant.

## **Water**

### *Surface water*

Penoxsulam is broken down in water by photolysis and microbial degradation, but the key degradation pathway in water is photolysis. Factors such as water depth, water clarity, plant density, and season of application can influence photolytic degradation. Water half-life is typically shorter in the summer months with higher light and water temperatures.

Penoxsulam has low to moderate water solubility that increases as pH becomes more alkaline. Studies show the water solubility of penoxsulam in buffered water is:

- 6 ppm at pH 5.
- 408 ppm at pH 7.
- 1460 ppm at pH 9.

The pH in most Washington lakes typically ranges from 7.5 to 9 during the spring/summer treatment season, so penoxsulam should be soluble at this range of pH.

The registrant conducted two aquatic field dissipation studies for penoxsulam in Florida ponds. In the first study, researchers applied penoxsulam to achieve a whole pond rate of 150 ppb (maximum label rate). Penoxsulam dissipated in the 0.9-hectare pond with a calculated half-life of 24.8 days. In the second study, the researchers applied penoxsulam four times by subsurface injection, at approximately 28-day intervals, to achieve a whole-lake water concentration of approximately 20 ppb penoxsulam in the 12.2-hectare lake. Penoxsulam dissipated in the water with calculated half-lives of 15.4, 11.0, 12.1, and 11.7 days respectively, following each of the four applications. During the fourth treatment, the researchers added Rhodamine WT dye to determine the three-dimensional dispersal pattern in the lake water. The dispersion analysis indicated that the dye became widely dispersed throughout the lake by six hours post-treatment and that the dye completely mixed laterally and vertically by approximately one day post-treatment.

Ecology anticipates that use patterns for penoxsulam in Washington for submersed plants will be similar to fluridone use patterns where applicators maintain herbicide water concentrations at low levels (10-20 ppb), but for an extended time. Typically, applicators monitor water concentrations and reapply more chemical at intervals to maintain target herbicide levels. Therefore, penoxsulam may be present in the water by design throughout a growing season, albeit at very low concentrations.

As a slow-acting systemic herbicide, penoxsulam should have minimal impact on dissolved oxygen levels in a treated waterbody, even if used as a whole lake or large block treatment

for submersed species. With systemic herbicides, plants die back slowly and biological oxygen demand (and nutrient release) from decomposing plants typically occurs over weeks and months. Field measurements in Washington lakes after whole lake fluridone treatments (fluridone affects plant die back similarly to penoxsulam) show only slight oxygen sags after treatment. Ecology expects similar oxygen levels after penoxsulam treatments.

There may be increased concentrations of phosphorus in the water column after penoxsulam treatments, particularly if used for whole-lake treatments. Because penoxsulam causes plants to die slowly over weeks to months, the release of nutrients into the water occurs slowly. However, phosphorus is often a limiting nutrient for algae growth, so whole-lake penoxsulam treatment may result in increased phytoplankton blooms in the water body. Increased phytoplankton blooms typically occur after extensive fluridone treatments, but not always. King County observed that many years of whole-lake fluridone treatments in Pipe and Lucerne Lakes for hydrilla eradication did not result in an overall decline in water clarity in those lakes. Secchi depths remained consistent or even improved in the lakes over this long-term project ([http://your.kingcounty.gov/dnrp/library/archive-documents/wlr/waterres/smlakes/hydrilla\\_IAVMP\\_04.pdf](http://your.kingcounty.gov/dnrp/library/archive-documents/wlr/waterres/smlakes/hydrilla_IAVMP_04.pdf)). However, these lakes are oligotrophic or meso-oligotrophic and trophic status may influence how lakes react to herbicide treatments.

Project proponents proposing whole lake or large-scale treatments with penoxsulam should develop a plan that recognizes the potential for follow-on phytoplankton blooms (including the potential for toxic cyanobacterial blooms in eutrophic waters). Planning for potentially toxic cyanobacterial blooms and communicating that risk to lake residents is particularly important in nutrient-enriched lake systems.

#### *Dispersion*

Dispersion of penoxsulam into non-treatment areas though in-water treatment may occur depending on many environmental factors including size of the treated area, wind, circulation patterns, currents, inflows and outflows, etc. Because it is slow acting and needs a long contact time to be effective, the penoxsulam label does not recommend its use for submersed spot treatments (treated areas less than five acres). The Galleon SC label cautions against making in-water applications in areas subject to rapid dilution of water and/or where the applicator cannot maintain sufficient exposure to targeted vegetation, such as in small spot treatments or in-water shoreline treatments in larger bodies of water. With larger scale treatments and long-term projects for submersed plants, it is very likely that penoxsulam will disperse into areas where it is not intentionally applied. Ecology will mitigate for the propensity for dispersion into untreated areas by conditioning its water quality permits to allow more limited treatment areas for nuisance weed control projects (similar to the amount of treatment allowed for fluridone).

Avoiding spray drift during treatment of emergent plants is dependent on the applicator. The applicator must select appropriate application equipment and treat only when environmental conditions (wind speed, temperatures) allow for effective treatment conditions. The label provides treatment mitigations to reduce spray drift. It is a violation of the FIFRA label and the NPDES permit for an applicator to not follow the label.

#### *Ground water*

Penoxsulam is very mobile and has the potential to leach to ground water, but it has a low vapor pressure and is unlikely to volatilize from soil and water. The European Food Safety Authority concluded that a metabolite of penoxsulam, GSTCA could contaminate ground water above a drinking water limit of 0.1 µg/L following applications to sandy soil in rice fields. Given that there is no drinking water restriction even when used at the maximum label rate of 150 ppb, it is unlikely that ground water contamination from penoxsulam or its metabolites would exceed 150 ppb. California EPA also identified pesticides containing penoxsulam as having the potential to pollute ground water in their evaluation of penoxsulam.

#### *Public water supply*

Ecology anticipates no adverse effects to public water supplies due to exposure to penoxsulam from aquatic treatments. Drinking water penoxsulam concentrations must not exceed 150 ppb to meet the current EPA label requirement. However, at this rate, or at lower concentrations, there are no restrictions on consumption of treated water for potable use or by livestock, pets, or other animals. There are no EPA label restrictions on the use of treated water for recreational purposes including swimming and fishing. Water concentrations higher than 150 ppb violate the FIFRA label. If penoxsulam were to enter the ground water due to an aquatic treatment, ground water concentrations would be unlikely to approach 150 ppb from aquatic treatments.

Ecology's water quality permits make special provision to protect municipal and community water intakes if an herbicide treatment could potentially affect large numbers of the public. In these cases, the potentially affected water right holder must agree to the treatment before Ecology will issue permit coverage. Even with an EPA drinking water tolerance of 150 ppb, some affected customers may not feel comfortable drinking any chemical in their potable water supply.

Treatment with penoxsulam may also affect people with legal water rights or claims for irrigation water. The label restricts food crop irrigation until penoxsulam concentrations are determined to be less than or equal to 1 ppb. However, there is no restriction on the use of water treated with Galleon SC for turf irrigation if water concentrations are less than 30 ppb. If people want to use treated water for non-food plants (e.g., landscape ornamentals), they should contact the SePRO Corporation (for treatment with Galleon SC) prior to commencing irrigation if water concentrations exceed 1 ppb. If treating near an active irrigation water

intake, the applicator must request that the irrigator turn off the water intake until concentrations in the water are 1 ppb or less, except when irrigating turf or rice.

Ecology's water quality permit mitigates for the possible loss of irrigation water rights by allowing project proponents to provide an alternative water supply to affected parties holding irrigation water rights while irrigation restrictions are imposed.

## **Plants**

### *Aquatic plants*

Penoxsulam is effective on a wide range of aquatic plants, but performance and selectivity is dependent on water concentration, time of year, stage of growth, method of application, and water movement (Galleon SC Label). Plants controlled include duckweed (*Lemna* spp.), fanwort (*Cabomba caroliniana*), Eurasian watermilfoil (*Myriophyllum spicatum*), hydrilla (*Hydrilla verticillata*), Brazilian elodea (*Egeria densa*), and sago pondweed (*Stuckenia pectinata*). See the label for more species. Other aquatic plant species may be less susceptible to penoxsulam, particularly grasses (monocots).

Glomski and Netherland (2009) tested penoxsulam on variable-leaf milfoil (*Myriophyllum heterophyllum*) in two laboratory aquarium studies. Variable-leaf milfoil is a Class A noxious weed in Washington and mandated for eradication. Penoxsulam controlled variable-leaf milfoil by 27% to 91% in two studies. Control increased as concentrations increased to 20 ppb, but there was no difference noted between the 20-50 ppb rates. The authors reported that plants treated at 10-20 ppb had collapsed in the water column and had started to decompose one week prior to harvest.

Cheshier, et al. (2011) found that penoxsulam significantly reduced duckweed biomass at 25, 50, and 75 ppb, but concluded that higher concentrations of penoxsulam may be required for complete control of duckweed. Even at 75 ppb, there was still viable duckweed biomass in the treated tanks 12 weeks after treatment.

Madsen and Wersal (2008) applied penoxsulam alone, and penoxsulam plus diquat to water hyacinth and giant salvinia in tank experiments. The authors found that these treatments did not control giant salvinia at any rate. However, penoxsulam alone, applied at 1.4 oz/acre with a surfactant provided excellent control of water hyacinth. Penoxsulam combined with diquat or diquat alone provided significantly less control of water hyacinth. Diquat appeared to have an antagonistic effect on penoxsulam in this case.

True et al. (2010) found that penoxsulam did not control common reed (*Phragmites australis*), a Class B noxious weed in Washington. However, grasses are reported to be resistant to penoxsulam.

Florida researchers reported that their initial use pattern for ALS herbicides mimicked the use patterns for fluridone (low use rate and long-term exposure); however, their research findings and field observations resulted in subsequent significant changes in the use patterns of both penoxsulam and another ALS inhibitor herbicide - imazamox. Florida now recommends using a tank mix with low use rates of endothall and penoxsulam and not using extended “bump” applications that increase long-term exposure. This change was to ameliorate concerns about adverse effects on sensitive non-target native species from the long exposure times. Haller (2011) reported that penoxsulam provides hydrilla control at concentrations of less than 40 ppb.

#### *Non-target plants*

Grasses and narrow-leaved monocots can tolerate low levels of penoxsulam. Koschnick, et al. (2007) conducted trials to determine the effect of penoxsulam on non-target emergent plants (soft-stem bulrush, Egyptian panicgrass, maidencane, pickerelweed, and arrowhead) in Florida. The authors found that the grasses tested were more tolerant of penoxsulam treatment than broadleaf monocots. Their data suggested that emergent grasses would be relatively tolerant to single applications of penoxsulam at 25 ppb.

Madsen et al. (2011) conducted a mesocosm study to determine the dose response of selected submersed and emergent native species to penoxsulam and imazamox (see the imazamox section of this document for the imazamox results). The emergent plants included arrowhead (*Sagittaria latifolia*), bulrush (*Scirpus acutus*), and fragrant water lily (*Nymphaea odorata* – a noxious weed in WA). The native submersed species were coontail (*Ceratophyllum demersum*), sago pondweed (*Stuckenia pectinata*), water celery (*Vallisneria americana* – not native plant in WA), Canadian waterweed (*Elodea canadensis*), and American pondweed (*Potamogeton nodosus*). Eurasian watermilfoil (*Myriophyllum spicatum*) was the invasive submersed species. The authors applied penoxsulam to the water column at 3, 6, and 12 ppb as a static exposure for 60 days. At these concentrations, penoxsulam did not affect any of the plants, except that the authors observed a growth regulating effect on *Elodea canadensis* (biomass reduced but the plants showed no signs of being chlorotic or necrotic).

#### *Algae*

The Galleon SC label does not claim any efficacy for algae control, but some of the toxicity data produced by the registrant indicates that penoxsulam may be toxic to some genera of algae. The 96 hour EC<sub>50</sub> for the freshwater green alga *Selenastrum capricornutum* is 0.0864 ppm (cell density), the 120-hour EC<sub>50</sub> for the freshwater blue-green alga *Anabaena flos-aquae* is 0.49 ppm (cell density), but the 120-hour EC<sub>50</sub> for freshwater diatom *Navicula pelliculosa* is 49.6 ppm (cell density). That penoxsulam is toxic to some algae is not surprising since algae and cyanobacteria have many of the same enzyme systems as higher plants.

In a study designed to test potential algaecidal activity of several ALS inhibiting herbicides, Netherland et al. (2009) found that penoxsulam was highly active against *Cylindrospermopsis* and *Anabaena* (bloom-forming cyanobacteria genera that can produce harmful toxins) as well as the green algae *Scenedesmus* at concentrations of 100 ppb. Penoxsulam reduced chlorophyll-a levels by >90% with these algae. A 100 ppb treatment reduced *Pseudanabaena* chlorophyll-a by 58%, while concentrations of penoxsulam of 200 and 500 ppb reduced chlorophyll levels by 85 and 90% respectively. Penoxsulam did not reduce chlorophyll-a for the cyanobacteria *Microcystis* or green algae *Ankistrodesmus* and *Selenastrum*. Although penoxsulam reduced cells of a beneficial green algal species, there was no indication that it would be active against a broad range of green algae. Based on the above test results, treatment with penoxsulam may result in some suppression or control of algae, but generally suggested use rates for penoxsulam will be well below the effective range to kill or suppress algae.

## Animals

Below is a table that summarizes some of the penoxsulam acute toxicity data to non-target aquatic organisms. The registrant submitted these data to EPA during the registration process.

**Table 1 – Penoxsulam toxicity information**

Freshwater Organism Studies			
Study	Organism	Results	EPA Toxicity Category
Fish 96 hour LC <sub>50</sub>	Bluegill	>103 mg/L	Practically non-toxic
Fish 96 hour LC <sub>50</sub>	Rainbow Trout	>102 mg/L	Practically non-toxic
Fish 96 hour LC <sub>50</sub>	Common carp	>101 mg/L	Practically non-toxic
Crustacean 24 and 48 hour EC <sub>50</sub>	<i>Daphnia magna</i>	>98.3 mg/L	Slightly toxic
Avian Studies			
Avian 8 day LC <sub>50</sub>	Mallard Duck	4310 mg/L	Practically non-toxic
Avian 8 day LC <sub>50</sub>	Bobwhite Quail	4411 mg/L	Practically non-toxic
Marine Organism Studies			
Mollusk 96 hour EC <sub>50</sub>	Eastern Oyster	127 mg/L	Practically non-toxic
Crustacean 96 hour LC <sub>50</sub>	Mysid Shrimp	114 mg/L	Practically non-toxic
Algae 120 hour EC <sub>50</sub>	<i>Skeletonema costatum</i>	44 mg/L	Slightly toxic

All studies shown conducted with penoxsulam technical. LC<sub>50</sub> concentration at which 50 % of test organisms exhibit a lethal response. EC<sub>50</sub> concentration at which 50 % of test organisms exhibit a lethal response.

### *Birds and aquatic mammals*

A European risk assessment for penoxsulam use in rice fields examined species representing insectivorous birds (wren), omnivorous birds eating large aquatic insects and aquatic plants (mallard), large herbivorous birds (geese), and piscivorous birds (heron).

Evaluators determined that there was a low risk to birds from the use of penoxsulam in rice fields.

They also considered the risk to small herbivorous mammals (water vole), the water shrew (eats aquatic invertebrates), and otter (eats fish and amphibians). Evaluators concluded that penoxsulam use in rice fields posed a low risk to these mammals. For both birds and mammals, this risk evaluation included exposure from the intake of contaminated paddy water to the estimated daily dose of penoxsulam. Overall, the evaluators concluded that the potential for bioaccumulation and secondary poisoning was low for birds and mammals. Their evaluation also included any penoxsulam metabolites. They concluded that even if the metabolites were ten times more toxic than penoxsulam, the risk for exposure to these metabolites would be as low as the risk from penoxsulam.

For aquatic treatments in Washington, waterfowl are likely to be the most exposed type of birds, since they swim, drink, and feed on lakes and wetlands that could be treated with penoxsulam. However, data indicate that penoxsulam is practically nontoxic to birds, water concentrations should not exceed 150 ppb (under typical treatment scenarios, exposure will likely be much less), and penoxsulam does not bioaccumulate. EPA concluded in its EFED that the acute lethality risk and chronic risk to birds and reptiles following ground spray or a granular application is likely to be very low. Therefore, Ecology does not expect any adverse impacts to birds from in-water or foliar treatments of penoxsulam. However, there can be effects to aquatic plants that may affect waterfowl through removal of food and habitat.

In mammalian metabolism studies, mammals rapidly and almost completely absorbed penoxsulam upon oral administration. There was no evidence of bioaccumulation. Excretion was rapid, but dose and sex dependent.

EPA similarly found that the risk quotient for all classes of mammals consuming all feed types is less than the level of concern. EPA indicated that adverse effects are not expected from the ground spray or granular application of penoxsulam. However, there can be effects to aquatic plants and that may affect aquatic mammals through removal of their food and habitat.

### *Fish*

Penoxsulam exhibited low toxicity to both warmwater and coldwater fish in toxicity studies. EPA considers that penoxsulam has low potential to bioaccumulate in fish. Ecology does not expect any adverse impacts to fish from penoxsulam use and does not plan to impose any fish timing restrictions on the use of penoxsulam. However, there can be effects to aquatic plants that may affect fish through removal of their cover and habitat. The tolerance for combined residues or residues of penoxsulam in or on fish,

shellfish, and mollusks is 0.02 ppm; for fish 0.01 ppm; and for fish, shellfish and crustaceans 0.01 ppm.

#### *Invertebrates*

Penoxsulam demonstrated low toxicity to bees, green lacewings, parasitic wasps, and predatory mites in laboratory and field studies. The 48 hour oral LC<sub>50</sub> for honeybees was 110 µg/bee - EPA considers this value to be practically nontoxic to bees.

The European risk assessment for the use of penoxsulam in rice fields evaluated a worst-case risk assessment for sediment-dwelling organisms for both penoxsulam and metabolites, assuming that the toxicity of the metabolites was equal to that of penoxsulam. Reviewers concluded that there was a negligible risk for penoxsulam and its metabolites to benthic invertebrates.

*Aquatic invertebrates* - Penoxsulam was slightly toxic to the water flea *Daphnia magna*. However, label use rates for penoxsulam are nearly a thousand-fold lower than the LC<sub>50</sub> for *Daphnia*. At the exposure rates proposed for use, Ecology does not foresee any adverse impacts to aquatic invertebrate populations from penoxsulam.

Researchers studied the bioaccumulation of penoxsulam in crayfish (*Procambarus clarkii*) at a concentration of 500 ppb under flow-through aquarium conditions. The exposure period was 14 days. The depuration period was 7 days. The maximum concentration of total residues in the tail muscle was 14.4 ppb at 11 days. The average steady-state calculated bioconcentration factor was 0.02 mL/g. After 5 days of depuration, researchers did not detect any total residues in the crayfish tissue.

#### *Threatened and endangered species*

With low use rates and lack of toxicity to aquatic and terrestrial animals, Ecology does not anticipate any direct impacts to threatened and endangered animal species from the use of penoxsulam. ALS inhibitors target a biochemical pathway that exists in plants, but not in animals. However, there may be indirect impacts to threatened and endangered animals from the removal of plants as food, cover, and habitat. There may also be improvements to food and habitat if managers use penoxsulam to remove aquatic invasive plants that may be blocking passage, lowering oxygen, raising water temperatures and pH, reducing species diversity, or providing hiding places for predators. Effects are project-dependent.

Ecology mitigates indirect effects of food and habitat loss through its permitting process by requiring work windows or consultation with the Washington State Department of Fish and Wildlife (WDFW) when herbicides are used in water bodies with priority species (includes threatened and endangered species) and habitats. Ecology's permit

manager also consults the Department of Natural Resources (DNR) Natural Heritage Program database for priority habitats, plants, and animals before issuing permit coverage for in-water treatments. If applicable, Ecology coordinates mitigation efforts with the permit applicant, WDFW, the Natural Heritage Program and others, if appropriate, to ensure adequate protections to threatened and endangered species and state priority species and habitats from herbicide use.

Because of possible sub-lethal impacts to juvenile anadromous salmonids, Ecology imposed timing restrictions on the use of some chemicals in its water quality permits. However, because penoxsulam is practically non-toxic to fish and is used at very low rates, Ecology does not plan to impose penoxsulam treatment timing windows for fish (salmon, bull trout, or steelhead) in its water quality permits at this time. This could change should additional data become available showing sub-lethal effects. However, timing restrictions for other priority species will remain in effect due to the potential for possible habitat loss.

Perhaps the most serious environmental impact from the use of penoxsulam could occur to rare floating or submersed plant species. Although penoxsulam exhibits some selectivity, a long exposure time and systemic properties could affect rare plants, particularly submersed or floating species when conducting lake-wide treatments. According to the EPA EFED, penoxsulam exceeds the level of concern for aquatic vascular plants and terrestrial monocots and dicots.

Applicators may only apply penoxsulam legally under water quality permits that make provision for mitigations for rare plants. Before issuing permit coverage, Ecology's permit manager consults the Natural Heritage Program database to determine the presence of any aquatic rare plants. If present, the applicant typically must hire a botanist to survey the water body. The permit manager consults with the Natural Heritage Program botanist, and the applicant to select appropriate mitigation measures to protect the rare plant populations. The permit manager may also request that Ecology's Aquatic Weeds Program botanist survey the lake before and after treatment and may request changes in mitigation procedures based on survey outcomes.

For some rare plant species, penoxsulam may not be an appropriate herbicide choice. In these cases, Ecology will work with the applicant to select a more appropriate herbicide, develop a mitigation plan that allows its use, or recommend a non-chemical management method.

## Water, land, and shoreline use

### Humans

Below is a summary table of some of the toxicity endpoints used for evaluating the risks to humans determined during EPA-approved toxicity testing during the registration process for penoxsulam.

**Table 2 – Acute toxicity endpoints**

Acute Toxicity Studies			
Study	Organism	Results	EPA Toxicity Category
Acute oral toxicity LD <sub>50</sub>	rat	>5,000 mg/kg bw	IV
Acute inhalation LC <sub>50</sub>	rat	>3.5 mg/l (highest attainable concentration)	III
Acute dermal LC <sub>50</sub>	rabbit	>5,000 mg/kg bw	IV
Acute dermal sensitization	guinea pig	Not a sensitizer	
Primary dermal irritation	rabbit	Slight, transient irritation	
Primary eye irritation	rabbit	Mild ocular irritation that cleared within 72 hours	

In its *Penoxsulam Fact Sheet*, EPA concluded, that there were *no risks of concern from the use of penoxsulam...penoxsulam is not expected to pose an acute risk...The risk due to exposure to residues in food and water was calculated below the Agency's level of concern for all population subgroups, including infants and children.*

*Eye and skin irritation:* Eye contact with penoxsulam liquid concentrate formulations may cause slight, temporary irritation, although corneal injury is unlikely. Brief skin contact is essentially nonirritating and unlikely to result in adsorption of harmful amounts. A single inhalation of mist from liquid formulations is not likely to cause adverse effects. The acute oral and acute dermal LD<sub>50</sub> in male and female rats was >5000 mg/kg. The acute dermal LD<sub>50</sub> in male and female rabbits was >5000 mg/kg. Penoxsulam did not cause allergic skin reactions when tested in guinea pigs. Therefore, Ecology has concluded that there should be no eye or dermal impacts to bystanders during a penoxsulam application.

*Lifetime exposure to penoxsulam in the diet of mice and rats was associated with an increase in large granular lymphocyte leukemia in male rats but not in male or female mice or female rats. The finding was considered weak and not conclusive because it was only observed in one sex and one species, there was no observed effect of increasing dose over a 50-fold range, and the levels of leukemia observed were consistent with historical controls for these types of test animals. No further testing was required by EPA (<http://www.epa.gov/opprd001/factsheets/penoxsulam.pdf>).*

As a result of the above findings, EPA classified penoxsulam as *suggestive evidence of carcinogenicity, but not sufficient to assess human carcinogenic potential* and did not recommend quantification of human cancer risk. EPA uses the term - *suggestive evidence of carcinogenicity but not sufficient to assess human carcinogenic potential* - when evidence from human or animal data is suggestive of carcinogenicity. This raises a concern, but is judged not sufficient for a conclusion as to human carcinogenic potential. Examples of such evidence may include a marginal increase in tumors that may be exposure-related, or evidence is observed only in a single study, or the only evidence is limited to certain high background tumors in one sex of one species. Dose-response assessment is not indicated for these agents ([http://npic.orst.edu/chemicals\\_evaluated.pdf](http://npic.orst.edu/chemicals_evaluated.pdf)).

New York State toxicologists (in their independent review of penoxsulam for registration in New York) also concluded that although laboratory data indicated that penoxsulam showed some evidence for carcinogenic potential in male rats, the evidence of carcinogenicity is relatively weak. They concluded that given the very low use rates for penoxsulam, it should not pose a risk to humans when used as an aquatic herbicide.

EPA calculated an oral reference dose of 0.147 mg/kg/day for penoxsulam based on a NOEL of 14.7 mg/kg/day in a one-year dog feeding study and an uncertainty factor of 100. By comparison, drinking water with 150 ppb penoxsulam would contribute approximately 0.004 and 0.015 mg/kg-day for adults and children respectively.

Penoxsulam did not cause birth defects in laboratory test animals. In subchronic and chronic feeding studies in rats and dogs, the most sensitive target organ was the urinary system. Due to limited solubility in urine, penoxsulam (and/or its metabolites) formed crystals that apparently irritated the urinary system.

The EPA Hazard Identification Assessment Review Committee (HIARC) concluded that there is no concern for neurotoxicity resulting from exposure to penoxsulam. Researchers did not find evidence of neurotoxicity in acute or chronic neurotoxicity studies in rats or in any of the subchronic or chronic feeding studies in rats, mice, or dogs. They did not observe any development toxicity at the highest dose tested.

Effects that EPA considered indicative of potential endocrine disruption include kidney crystals in female rats and delay in preputial separation in male rats, an indicator of sexual maturation. EPA may subject penoxsulam to additional screening and/or testing to better characterize effects related to endocrine disruption. Although EPA initiated testing of pesticides for endocrine disruption in 2009, penoxsulam was not on the initial list of compound to be screened. EPA selected the initial list of pesticides based on exposure potential only.

There have been no reports of alleged human health effects associated with penoxsulam reported to the EPA and searches of the open literature by the European Food Safety Authority produced no reports of adverse effects in human related to penoxsulam exposure.

Given the potentially lengthy treatment scenarios proposed for penoxsulam treatments, Ecology expects that people will be exposed to low concentrations of penoxsulam through recreational activities. However, because of the very low acute mammalian toxicity and use rates, Ecology does not believe that penoxsulam poses any risk to human health when used at label rates.

#### *Navigation*

Penoxsulam has no use restrictions and its application to a waterbody should not interfere with boating or navigation. However, removal of dense surfacing mats of aquatic vegetation may improve the safety and navigability of a water body.

#### *Swimming*

Penoxsulam has no swimming restrictions. Given low use rates, low toxicities, and only very mild eye and skin irritation potential, Ecology sees no reason to recommend a 24-hour swimming advisory after treatment. Removal of aquatic vegetation from a designated swimming area may improve swimmers safety and allow lifeguards or parents' better visibility should a swimmer experience difficulties.

#### *Fishing*

Penoxsulam has no fishing or fish consumption restrictions and its use should have no effect on fishing, except that open areas of water may enhance the fishing experience because lines will not snag on vegetation. However, removal of aquatic plants, particularly during any whole-lake treatments may influence fish use patterns and fishers may need to alter fishing strategies to be successful. Negative effects on warm water fisheries have been reported (anecdotal reports from WDFW biologists) after whole lake fluridone treatments when much of the submersed vegetation was removed. Prey species (sunfish) lose hiding places and are vulnerable to predator species such as bass. Some fisheries biologists in Washington have reported a loss of sunfish species (also non-native species in Washington) after whole lake herbicide treatments for noxious weed eradication. Ecology's water quality permits limit the amount of littoral zone that applicators may treat for nuisance plant removal projects. That should leave untreated native plants as refugia for fish and wildlife.

#### *Agriculture*

Irrigation using water treated with penoxsulam may result in injury to sensitive irrigated vegetation. The label prohibits irrigating greenhouse or nursery plants and hydroponic farming. The label prohibits the use of penoxsulam treated water to irrigate food crops (other than rice) until the water concentration is 1ppb or less.

#### *Data gaps*

Penoxsulam produces 13 different identified degradates. Six of these degradates seem to have a greater degree of persistence than penoxsulam.

## 4. Mitigation

- Follow current label requirements.
- Use state-licensed applicators.
- Where required, apply penoxsulam under Ecology water quality permits and follow all permit provisions. The special conditions in the permit provide mitigations for herbicide use in general and Ecology sets out any specific provisions for each chemical in its permits.
- Ecology may require ground water monitoring in areas of cracked basalt or with permeable soils in water bodies being treated with penoxsulam.
- Do not use in areas where there are rare submersed or floating plant species unless Ecology agrees to the mitigation plan.

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## Evaluation of imazamox

*Imazamox*: 2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-(methoxymethyl)-3-pyridinecarboxylic acid. Ammonium salt.

### 1. Registration status

The American Cyanamid Corporation (acquired by BASF in 2000) first introduced imazamox in Europe in 1995. EPA granted a conditional registration for imazamox in 1997 and an unconditional registration section 3 label in 2001. In 2003, imazamox received an exemption for tolerance designation from the EPA. The exemption waives all food residue tolerance requirements for potential food or feed uses of imazamox, including fish, shellfish, crustaceans, and irrigated crops. Imazamox is the first and only organic pesticide to receive a tolerance exemption.

The EPA considers imazamox to be a reduced risk pesticide with both terrestrial and aquatic uses. Although EPA first approved imazamox for use on soybeans, it is currently used on 15 different crops on a worldwide basis. Experimental work with Clearcast™, the aquatic and non-crop liquid formulation of imazamox began in 2004. Aquatic Experimental Use Permit programs included as many as 16 states and treatment areas up to 4,750 acres per year. Clearcast™ received full registration in 2008.

All active formulations of imazamox are registered to BASF, although the SePRO Corporation now markets Clearcast® for BASF. There is also a FIFRA Section 24(c) Special Local Need Label issued to the state of Florida for Clearcast®. Washington has registered Clearcast™.

BASF submitted the toxicity, ecotoxicity, and environmental fate studies pertaining to imazamox to Ecology to support the development of this EIS (88 separate studies submitted). In addition, BASF collaborated with the New York State Department of Conservation and the ENSR Corporation to prepare a supplemental EIS for "*Use of Aquatic Herbicide Imazamox Clearcast® in the State of New York*". Ecology used this document and the toxicity, ecotoxicity, and environmental fate studies in preparation of the imazamox section of this SEIS.

## 2. Description

Imazamox is an imidazolinone herbicide that inhibits the acetolactate synthase (ALS) enzyme that is essential for the synthesis of three branched chain amino acids isoleucine, leucine, and valine. The lack of ALS biochemical pathways in animals likely contributes to the low toxicity of imazamox in mammals and other animal taxa. Currently Ecology allows the use of another imidazolinone herbicide, imazapyr for use in freshwater and marine environments, although unlike imazamox, imazapyr does not demonstrate any in-water herbicidal activity.

The aquatic formulation, Clearcast®, consists of 12.1% imazamox ammonium salt and 87.9% other ingredients. It contains one-pound imazamox acid equivalent per gallon of product. BASF considers the identities of the other ingredients (formerly referred to as inerts) proprietary information. However, the MSDS for Clearcast® does not specify any toxic or specially regulated ingredients. This indicates that none of the other ingredients present in Clearcast® (at a concentration of 1% or more) is classified as hazardous. MSDSs must list hazardous chemicals that are found in a product in quantities of 1% or greater, or 0.1% or greater if the chemical is a carcinogen ([www.ehso.com/msds\\_regulations.php](http://www.ehso.com/msds_regulations.php)).

*Typical aquatic use:* Clearcast® is considered a selective herbicide; generally, dicots are less sensitive than monocots. Applicators may apply imazamox into the water for the control of submersed vegetation or spray it directly onto emergent plants. However, application to emergent plants requires the use of an adjuvant. Ecology lists adjuvants approved for aquatic use in its water quality permits. Aquatic sites labeled for treatment include estuarine and marine sites, ponds, lakes, reservoirs, wetlands, marshes, swamps, ditches, canals, streams, rivers, and other slow-moving or quiescent bodies of water. Applicators may also use imazamox during drawdown conditions.

The maximum label concentration is 500 ppb for in-water applications, but in-water use rates are expected to be lower, typically between 50 and 200 ppb depending on the target species. The label allows multiple applications during the annual growth season, but does not specify retreatment intervals or the maximum amount of active ingredient that can be applied each growing season (other than limiting the maximum water concentration to 500 ppb). Imazamox is a fast acting herbicide and there is no need to maintain concentrations in the water column for an extended period to achieve good control of submersed species. The maximum label rate for foliar broadcast applications is two quarts per acre or 0.5 pounds active ingredient per acre. For foliar spot applications, the maximum rate is up to 5% by volume. For drawdown applications, the label specifies that applications should be made when the water has receded and the exposed soil is moist to dry.

Imazamox is a systematic herbicide that is rapidly absorbed into the foliage and translocated throughout the plant via phloem and xylem tissues. It concentrates in the actively growing portions of roots and shoots. Imazamox inhibits plant growth within the first 24 hours after application, but visual symptoms appear about one week after treatment with symptoms evident first on new growth. Susceptible plants develop a yellow appearance or general discoloration and eventually die or suffer severe growth inhibition. For emergent applications, BASF claims that Clearcast® is rainfast within one hour of application.

### **3. Environmental and human health impacts**

This section describes anticipated impacts of using imazamox herbicide to control freshwater aquatic plants on the environment, aquatic biota, and human health. Ecology recommends mitigation measures, when appropriate. Applicators may use imazamox at concentrations no greater than the maximum-labeled rate in lakes, ponds, and reservoirs, and estuarine and marine sites. These imazamox concentrations pose negligible risk to the environment and non-target species based upon testing conducted under EPA guidelines.

#### **Earth**

##### *Soils*

Imazamox degrades slowly when applied to upland soils. Field studies showed that imazamox dissipated with half-lives of 130, 50, 35, 15, and 50 days at field sites in North Dakota, Georgia, Arkansas, Iowa, and California respectively. However, Ecology expects no impacts to soils from the application of imazamox products to water bodies in Washington State because there should be minimal exposure. Ecology does not anticipate drift onto soils through application to freshwater submersed, floating, or emergent plants. Information on the label, such as controlling droplet size, helps applicators control off-target drift when treating emergent or floating leaved vegetation using application

equipment such as backpack sprayers or hoses. Applicators typically apply granular formulations (if a granular product becomes available) from hand-held spreaders or spreaders mounted on boats and apply liquid formulations through subsurface hoses for submersed plant treatment.

Applicators must follow all mixing and loading procedures found on herbicide labels to prevent spills on unprotected soil. In the event of a spill, applicators must follow spill response procedures outlined in the water quality permit. Ecology recommends no additional mitigation other than following the label.

#### *Sediment*

In sediment, imazamox half-lives ranged from 15 to 130 days in field studies. It is highly water-soluble and imazamox is not expected to bind with organic materials. Imazamox is persistent in anaerobic conditions.

#### **Air**

Vapor pressure of imazamox is  $1.33 \times 10^{-5}$  Pa at 25° C and Henry's law constant is  $9.76 \times 10^{-7}$  Pa m<sup>3</sup> mol<sup>-1</sup> at 25° C. The aquatic formulation of imazamox is considered to be non-volatile and relatively non-toxic by inhalation. There should be little to no inhalation exposure to the applicator or to bystanders during an aquatic application.

Ecology expects any adverse impacts to air quality from the use of imazamox to be minimal and associated with a small amount of petroleum exhaust emissions related to the use of application equipment.

#### **Water**

##### *Surface water*

In aquatic environments, photolytic degradation and dilution are the primary sources of the dissipation of imazamox, but the key degradation pathway is photolysis (breaks down by light). Imazamox degrades rapidly in light (half-life of 6.8 hours) and degradation proceeds via microbial action to carbon dioxide. Factors such as water depth, water clarity, and season of application can influence photolytic degradation. Based on laboratory tests and field trials, the half-life of imazamox in water ranges from 5-15 days with the length in water dependent upon water clarity, depth, vegetative cover, and available sunlight.

Without light, imazamox is stable to degradation and in anaerobic conditions, its half-life is greater than two years. Imazamox should not persist in well-lit, oxygenated surface waters, but it may persist in darker, less oxygenated water such as below the thermocline in some lakes. EPA concluded that even if imazamox does persist at greater water depths, it still is unlikely to present a risk to fish, invertebrates, birds, or mammals.

## Solubility of imazamox in water at 25° C

- pH 5: 116 g/L
- pH 7: >626 g/L
- pH 9: >628 g/L

The solubility data indicate the imazamox is highly soluble in water, particularly at the pH levels commonly found in Washington lakes during the treatment season. High water solubility is frequently associated with mobility. Mobile chemicals have a greater probability of moving to ground water.

Nissen, et al. (2007) monitored weed control and imazamox dissipation from May to August in two small Colorado lakes treated for Eurasian watermilfoil. They reported that imazamox concentrations in these lakes, decreased rapidly after application due to photodegradation. They estimate that the half-life of imazamox in these aquatic ecosystems was approximately four days. The authors also note that these imazamox treatments significantly reduced the growth of Eurasian watermilfoil, keeping these lakes completely open all summer.

Thurston County, Washington staff reviewed imazamox for use in its aquatic plants management programs and concluded: *In shallow or clear water imazamox can break down quickly in sunlight, in deep or cloudy water it can be expected to persist for months, and in sediment it can persist for years. Since imazamox is not expected to bind well to sediment, accumulation within the sediment is unlikely. The hazard for imazamox to persist in the water column is moderate but it is high in sediments. The overall hazard of aquatic persistence for imazamox is rated moderate because imazamox is very soluble in water and is not expected to preferentially bind to sediment, so the majority of chemical will be broken down in the water column.*

Ecology expects that as a systemic herbicide, imazamox should have minimal impact on dissolved oxygen levels in a treated waterbody. Plants generally die back slowly after treatment with systemic herbicides and biological oxygen demand from decomposing plants typically occurs over weeks rather than days such as occurs with contact herbicides. However, there may be increased concentrations of organic and inorganic phosphorus in the water column after treatments with imazamox due to nutrient release from decomposing vegetation.

### *Dispersion*

Dispersion of imazamox into non-treatment areas though in-water treatment may occur depending on many environmental factors including size of the treatment area, wind, circulation patterns, currents, inflows and outflows, etc. However, compared to other ALS inhibitors and fluridone that need prolonged contact times, imazamox does not

require "bump" applications to maintain water concentrations over extended periods. This helps limit any off-target dispersion because the applicator will typically only need to apply imazamox once (or possibly) twice per growing season.

Avoiding spray drift during treatment of emergent plants is dependent on the applicator. The applicator must select appropriate application equipment and treat only when environmental conditions (wind speed, temperatures) allow for effective treatment conditions. The label provides treatment mitigations to reduce spray drift. It is a violation of the FIFRA label and the NPDES permit for the applicator to not follow label directions.

#### *Ground water*

California EPA identified pesticides containing imazamox as having the potential to pollute ground water. Because imazamox has high water solubility, it has the potential to affect ground water. However, in well-lit waters, imazamox should break down quickly. When treating in deep lakes or lakes with turbid water where imazamox may persist, the applicator should check for direct interchange between the treated water and groundwater that supplies local drinking wells.

#### *Public water supply*

Ecology anticipates no adverse effects to public water supply due to exposure to imazamox from aquatic treatments. There are no use restrictions on livestock watering, swimming, fishing, or domestic use. Applicators may apply imazamox to potable water sources at concentrations up to 500 ppb so long as the application area is not within one-quarter mile from an active potable water intake. Within a one-quarter mile radius of an active potable water intake, imazamox water concentrations may not exceed 50 ppb. If the treatment plan requires imazamox water concentrations greater than 50 ppb within a quarter mile of a potable water intake, the user must shut off the intake and use an alternate water supply until imazamox water concentrations are below 50 ppb.

Ecology's water quality permits mitigate for water use restrictions, by requiring the permit holder to provide an alternative water supply if a treatment affects residential potable water use. For municipal or community drinking water sources potentially affected by treatments, Ecology's water quality permit requires that the water right holder approve the permit application to treat the water. This allows the public water purveyor to influence any herbicide treatments that could impact public water supplies.

## **Plants**

#### *Aquatic plants*

Imazamox controls a wide range of aquatic plants, but its effectiveness and selectivity is dependent on application rates and plant growth stages. Some of the noxious weeds found in Washington controlled with imazamox include common reed (*Phragmites australis*), parrotfeather (*Myriophyllum aquaticum*), variable-leaf milfoil (*Myriophyllum*

*heterophyllum*), water primrose (*Ludwigia hexapetala*), fragrant water lily (*Nymphaea odorata*), hydrilla (*Hydrilla verticillata*), Eurasian watermilfoil (*Myriophyllum spicatum*), purple loosestrife (*Lythrum salicaria*), and curly leaf pondweed (*Potamogeton crispus*). Native nuisance species controlled by imazamox include cattail (*Typha* spp.), water shield (*Brassenia schreberi*), and pondweeds (*Potamogeton* spp.).

Applicators can apply imazamox any time during the growing season for submersed plant control, but for best results, the label recommends that applicators apply imazamox early in the season when plants are actively growing. To maintain sufficient concentrations and contact times, applicators may need to use higher use rates when treating smaller areas or in areas of greater water exchange. In BASF's experience, tolerant species rapidly recolonize a site after treatment because imazamox is relatively short-lived in the water and sediment. Tolerant submersed species include coontail (*Ceratophyllum demersum*) and the macroalgae *Chara* spp. For foliar applications to floating-leaved or emergent plants, in-water imazamox concentrations after treatment should not be sufficient to cause injury to submersed species.

Vassios (2010) conducted several laboratory studies to determine the response of Eurasian watermilfoil to imazamox, a highly water soluble herbicide. He found that over 50 % of the imazamox plant uptake occurs in the first 24 hours after treatment and the remaining 50 % occurs in the next 48 hours. He expected the internal concentration of imazamox to be equal to the external concentration, but instead it was nearly 7 times the external concentration 72 hours after treatment. There appeared to be a linear relationship between the external concentration and the amount of imazamox absorbed by the plant. There was little evidence of translocation from the shoot to root tissue (only 2% in the root). Imazamox rapidly desorbed from the plant when the authors removed the plant from the treated water. Vassios noted in his thesis (but did not provide data) that imazamox can provide multiple season control of Eurasian watermilfoil at concentrations of 100-200 ppb.

Shuler, et al. (2011) documented emerging use patterns for Clearcast®, reporting effective control of curly leaf pondweed with short exposure requirements. The authors also report selective control of salt cedar (*Tamarix* spp.) seedlings and *Phragmites australis* and effective pre-emergent use of Clearcast® in dewatered irrigation canals for the control of sago pondweed (*Stuckenia pectinata*) and horned pondweed (*Zannichellia palustris*).

Nissen, et al. (2007) found that in small tank studies, Eurasian watermilfoil (*Myriophyllum spicatum*) was sensitive to 200 ppb imazamox, although sago pondweed (*Stuckenia pectinatus*) was not susceptible even up to 800 ppb. However, when applied to

soil, imazamox reduced sago pondweed biomass by 95% when the shoots emerged through the treated soil.

#### *Algae*

The Clearcast® label does not claim any efficacy for algae control. The registrant toxicity information for algae showed no effects at concentrations about 40 ppb.

#### *Non-target plants*

Although imazamox applied as an in-lake application to control submersed or floating leaved vegetation could potentially have an impact on native emergent wetland communities, Ecology considers this unlikely. Emergent plant species are not particularly susceptible to water column treatments. Elevated concentrations of imazamox should not persist in well-lighted and aerobic shorelines. However, improperly applied foliar applications could impact non-targeted emergent plants. Applicators are required to follow all label and water quality permit conditions that reduce non-target impacts.

Madsen et al. (2011) studied the dose response of selected submersed and emergent native species to imazamox in mesocosm studies. The emergent plants were arrowhead (*Sagittaria latifolia*), bulrush (*Scirpus acutus*), and fragrant water lily (*Nymphaea odorata* – a noxious weed in WA). The native submersed species were coontail (*Ceratophyllum demersum*), sago pondweed (*Stuckenia pectinata*), water celery (*Vallisneria americana* – not native in WA, but not a noxious weed), Canadian water weed (*Elodea canadensis*) and American pondweed (*Potamogeton nodosus*). Eurasian watermilfoil (*Myriophyllum spicatum*) was the invasive species. They applied imazamox at 25, 50, 100, or 200 ppb for 1, 3, or 7 days. At 12 weeks after treatment, submersed plants were largely unaffected by imazamox across concentration and exposure times, with the exception of *Elodea canadensis*. Imazamox reduced elodea biomass by growth regulating effects, but the plants were not chlorotic or necrotic. Arrowhead and bulrush were not affected at 12 weeks after treatment, but the fragrant water lily was reduced at the maximum rate and exposure time.

Vollmer (2009) reported that efficacious foliar rates of imazamox for the control of cattail, water hyacinth, and water lily, had no effect on submersed species such as *Najas*, *Chara*, *Ceratophyllum*, *Potamogeton*, and *Ruppia* species. In-water treatments used to control *Potamogeton crispus* did not affect shoreline plants like cattails or floating-leaved plants like water lilies. In non-target vegetation trials (conducted by the registrant), over the top foliar as well as directed soil applications to non-target cottonwood and willow trees caused only minor injury at the highest foliar rate of 0.5 pound ae/acre.

#### **Animals**

For all taxa except plants, the most sensitive species to imazamox was the sheepshead minnow with an LC<sub>50</sub> of >94.2 ppm and a Risk Quotient (RQ) of less than <0.001. RQs

less than 0.05 are below EPA's Level of Concern for acute effects, meaning that the toxicity result is negligible. An RQ of <0.001 suggests that the potential toxicity to non-target animals species from imazamox is negligible. A Thurston County assessment of imazamox concluded: *Adverse effects to non-target organisms from aquatic uses of imazamox herbicides are not expected and the risk of toxicity to pets and wildlife from aquatic applications of imazamox herbicides is rated low in hazard.*

Below is a summary table of acute toxicity endpoints for non-target aquatic organisms determined during EPA-approved toxicity testing during the registration process for imazamox.

**Table 3 – Toxicity to non-target organisms for imazamox**

Freshwater Organism Studies			
Study	Organism	Results	EPA Toxicity Category
Fish 96 hour LC <sub>50</sub>	Bluegill	>119 mg a.i./L	Practically non-toxic
Fish 96 hour LC <sub>50</sub>	Rainbow Trout	>122 mg a.i./L	Practically non-toxic
Invertebrate 48 hour EC <sub>50</sub>	<i>Daphnia magna</i>	>122 mg a.i./L	Practically non-toxic
Avian Studies			
Avian 5 day dietary LC <sub>50</sub>	Mallard Duck	>5572 mg a.i./L	Practically non-toxic
Avian 5 day dietary LC <sub>50</sub>	Bobwhite Quail	>5572 a.i. mg /L	Practically non-toxic
Marine Organism Studies			
Crustacean 96 hour LC <sub>50</sub>	Mysid Shrimp	>100 mg	Practically non-toxic
Algae 120 hour EC <sub>50</sub>	<i>Skeletonema costatum</i>	> 40 ppb	

### *Birds*

Imazamox is slightly-to-practically non-toxic to birds on an acute oral basis and on a sub-acute dietary basis. The LC<sub>50</sub> for sub-acute avian dietary assays was >5,573 ppm and there were no bird mortalities observed during avian toxicity testing. Avian reproductive studies showed the NOEC (No Observed Effect Concentration) and LOEC (Lowest Observed Effect Concentration) (ppm a.i.) at >2000 ppm for mallard and northern bobwhite quail. Waterfowl are likely to be the most exposed type of birds, since they swim, drink, and feed on lakes and wetlands that may potentially be treated with imazamox. However, imazamox is relatively non-toxic to birds, water concentrations should not exceed 500 ppb (and will likely be less), imazamox does not persist in well-lighted waters, or bioaccumulate. Therefore, Ecology does not expect any adverse impacts to birds from in-water or foliar treatments of imazamox.

### *Mammals*

Although EPA may require wild mammal testing depending on the results of acute and sub-acute testing, intended use pattern, and pertinent environmental fate characteristics, EPA did not require wild mammal testing for imazamox because rat toxicity testing showed that imazamox was practically non-toxic to mammals on an acute basis. ALS

inhibitor herbicides demonstrate low toxicity towards animals. This is likely because the ALS biochemical pathway does not exist in animals.

#### *Fish*

Imazamox is practically non-toxic to fish. At the highest concentration tested there were no observed acute adverse effects to fish or aquatic invertebrates from imazamox. EPA did not require chronic toxicity testing for fish because the estimated environmental concentration did not exceed 1% of the lowest LC<sub>50</sub>, making the chronic risk of imazamox to fish negligible. According to the EPA, imazamox does not bioconcentrate in fish and concentrations in fish following aquatic applications were below the limit of quantification.

Information from the fish studies showed that imazamox has a low potential for bioconcentration due to its low octanol/water partition coefficient ( $K_{ow} < 1$ ). Fish adsorbed and rapidly excreted imazamox and tissue concentrations declined to less than quantifiable limits during the first 24 hours of the depuration process. Based on imazamox behavior in fish, the potential for bioaccumulation and/or biomagnification in the aquatic food chain is low. Thurston County staff in reviewing imazamox concluded that *imazamox does not have a strong affinity to bind with organic solvents and testing indicates that it does not accumulate in fish tissue. Metabolism tests with rats shows that imazamox is quickly eliminated unmetabolized from the body when administered intravenously or when eaten. The hazard for imazamox to bioaccumulate is rated low.* EPA exempted imazamox from food tolerances.

#### *Invertebrates*

EPA did not require chronic testing for invertebrates because the estimated environmental concentration did not exceed 1% of the lowest LC<sub>50</sub>, making the chronic risk of imazamox to invertebrates negligible. The EC<sub>50</sub> values for the daphnid and mysid organisms are greater than 122 ppm and 94.3 ppm respectively. These values are well in excess of the maximum in-water label rate of 500 ppb for imazamox.

A honeybee acute contact study showed the LD<sub>50</sub> for bees was greater than 25µg bee, the highest dose tested. This falls into the EPA practically nontoxic category for bees. There should be little risk of exposure to imazamox for bees from in-water treatments. There may be more exposure from foliar treatments, but any exposure should not cause problems to bees. However, generally applicators try to treat emergent species that might attract bees, like purple loosestrife, before or after flowering.

#### *Threatened and endangered species*

With low use rates and lack of toxicity to aquatic and terrestrial animals, Ecology does not anticipate any direct impacts to threatened and endangered animal species from the use of imazamox. ALS inhibitors target a biochemical pathway that exists in plants, but not in animals. However, there may be indirect impacts to threatened and endangered

animals from the removal of aquatic plants as food and habitat. There may also be improvements to food and habitat if managers use imazamox to remove aquatic invasive plants that may be blocking passage, lowering oxygen, raising water temperatures and pH, reducing species diversity, or providing hiding places for predators. Effects are project-dependent.

Ecology mitigates indirect effects of food and habitat loss through its permitting process by requiring work windows or consultation with WDFW when herbicides are used in water bodies with priority species (includes threatened and endangered species). Ecology's permit manager also consults the DNR Natural Heritage Program database for priority habitats, plants, and animals before issuing permit coverage for in-water treatments or nuisance shoreline vegetation treatments (native vegetation). If applicable, Ecology coordinates mitigation efforts with the permit applicant, WDFW, the Natural Heritage Program and others, if appropriate, to ensure adequate protections to threatened and endangered species and state priority species from herbicide use.

Because of possible sub-lethal impacts to juvenile salmon, Ecology imposed timing restrictions on the use of some chemicals. However, because of low fish toxicities and low use rates of imazamox, Ecology does not plan to require timing windows for fish (salmon, bull trout, or steelhead) in its water quality permits for the use of imazamox. This could change should research indicate sub-lethal impacts to these fish from imazamox use. However, timing windows for other priority species will remain in effect due to the potential for possible habitat loss.

Perhaps the most serious environmental impact from the use of imazamox could occur to rare floating or submersed plant species. Typically, applicators may only apply imazamox legally under water quality permits that make provision for mitigations for rare plants. Before issuing permit coverage, Ecology's permit manager consults the Natural Heritage Program database to determine the presence of any aquatic rare plants. If present, the applicant generally hires a botanist to survey the water body. The permit manager consults with the Natural Heritage Program botanist, and the applicant to select appropriate mitigation measures to protect the rare plant populations. The permit manager may also request that Ecology's Aquatic Weeds Program botanist survey the lake before and after treatment to determine any impacts from the treatment.

For some rare plant species, imazamox may not be an appropriate herbicide choice. In these cases, Ecology will work with the applicant to select a more appropriate herbicide, develop a mitigation plan, or recommend a non-chemical management method. In some cases, Ecology may issue an administrative order to supplement the conditions in its general permits if those conditions are not protective enough.

## Water, land, and shoreline use

### Humans

Below is a summary table of some of the toxicity endpoints used for evaluating the risks to humans determined during EPA-approved toxicity testing during the registration process for imazamox.

**Table 4** –Toxicity studies for imazamox

Acute Toxicity Studies for Imazamox			
Study	Organism	Results	Toxicity Category
Acute oral toxicity - single dose (LD50)	rat	> 2121mg a.i./kg b.w.	
Acute inhalation	rat	> 6.3 mg/L	IV
Acute dermal	rabbit	>4000 mg/kg b.w.	III <sup>1</sup>
Acute dermal sensitization	guinea pig	Not a sensitizer	
Primary dermal irritation	rabbit	Non-to-slightly irritating	IV
Primary eye irritation	rabbit	Slight-to-moderately irritating	III
Subchronic Effects			
28 day dermal	rat	NOAEL <sup>2</sup> 1000 mg/kg b.w./day	No systemic toxicity at the HDT (highest dose tested)
13-week feeding study	rat	NOAEL > 20,000 ppm	No systemic toxicity at HDT
90-day feeding study	dog	NOAEL > 40,000 ppm	No systemic toxicity at HDT
Chronic Effects			
Tests indicate no oncogenic or teratogenic potential and no reproductive toxicity at the highest doses tested and negative activity in four mutagenicity studies. There were no effects on organs associated with endocrine function.			

Collective organ weight data and histopathological findings from the two-generation rat reproductive study, as well as from the sub-chronic and chronic toxicity studies conducted in two or more animal species demonstrate no apparent estrogenic effects or effects on the endocrine system. There is no information available that suggests that imazamox would be associated with endocrine effects.

Although the New York State Department of Health determined after reviewing the EPA toxicity data that imazamox was moderately irritating to rabbit eyes, they concluded that the aquatic formulation - Clearcast® was not very irritating. They also concluded that

<sup>1</sup> Toxicity Category III – Harmful if absorbed through skin. Causes eye irritation. Avoid contact with skin, eyes, or clothing. Wash thoroughly with soap and water after handling. Avoid breathing dust. Remove contaminated clothing and wash before reuse.

<sup>2</sup> NOAEL – No observable adverse effect level

neither the active ingredient nor the formulated product were very irritating to rabbit skin and did not cause dermal sensitization when tested on guinea pigs.

Imazamox did not cause any observable toxicity in sub-chronic or chronic feeding studies at high doses. There was no evidence of carcinogenicity in either the rat or the mouse studies and imazamox was negative in a number of genotoxicity studies. Based on these findings, the EPA designated imazamox as *not likely to be carcinogenic to humans*. Imazamox caused some maternal effects in developmental toxicity studies with reduced body weight at 1,000 mg/kg/day in pregnant rats and reduced food consumption at 600 mg/kg/day in pregnant rabbits.

In 1997, EPA established an oral reference dose of 3.0 mg/kg/day for imazamox based on a NOEL of 300 mg/kg/day from the developmental toxicity study in rabbits and an uncertainty factor of 100. In 2001, the EPA concluded that the use of 3 mg/kg/day was inappropriate because the endpoint of "decreased weight gain" was not biologically significant. Instead, the EPA suggested that the highest dose tested for these studies should be used as the actual no observable adverse effect level (rat = 1,068 mg/kg/day and rabbit = 900 mg/kg/day). Using the no observable adverse effect level of 900 mg/kg/day changed the dose of concern from 3 mg/kg/day to 9 mg/kg/day.

In its 2011 assessment of imazamox, Thurston County used 9 mg/kg/day dose of concern to assess risk for both short and long-term exposures to imazamox. Thurston County calculated that potential exposure to adult applicators of the aquatic formulation of imazamox to be at least 600 times less than the dose of concern (rated low in hazard).

Thurston County calculated a drinking water assessment for imazamox that included drinking from a treated surface water body. They calculated the potential exposure from short-term drinking of treated water to be 150 times less than the dose of concern (rated low in hazard).

#### *Navigation*

The application of imazamox to a waterbody should not interfere with boating or navigation. Removal of dense surfacing mats of aquatic vegetation may improve the safety and navigability of a water body.

#### *Swimming*

There are no swimming restrictions for imazamox on the aquatic label. Ecology believes that no swimming restrictions or advisories are appropriate because ClearCast® is not irritating to eyes or skin and is practically non-toxic to mammals. Given the low use rates and low mammalian toxicity, Ecology sees no reason to recommend a 24-hour swimming advisory after treatment. Removal of aquatic vegetation from a designated swimming

area may improve swimmers safety and allow lifeguards and parents better visibility should a swimmer experience difficulties.

#### *Fishing*

Imazamox has no fishing or fish consumption restrictions and its use should have no effect on fishing, except that it may remove dense plant beds to provide more fishing opportunities. However, removal of aquatic vegetation, particularly during any widespread treatments may influence fish use patterns and fishers may need to alter fishing strategies to be successful. Negative effects on warm water fisheries have been reported (anecdotal, Kathy Hamel) after whole lake fluridone treatments when much of the submersed vegetation was removed. Prey species (sunfish) lose hiding places and are vulnerable to predator species such as bass. Some fisheries biologists have reported a loss of sunfish species (also non-native species in Washington) after whole lake herbicide treatments for noxious weed eradication using the non-selective, systemic herbicide fluridone.

#### *Agriculture*

The label prohibits irrigating greenhouse or nursery plants and hydroponic farming with imazamox-treated waters. Treated waters resulting in imazamox concentrations >50 ppb may not be used for irrigation until residue levels have been shown to be ≤50 ppb. However, still or quiescent waters with an average depth of four or more feet receiving a foliar application (≤ two quarts per acre of Clearcast®) to floating or emergent vegetation may be used for irrigation 24 hours after application is completed.

## **4. Mitigation**

- Follow current label requirements.
- Use state-licensed applicators.
- Where required, apply imazamox under Ecology water quality permits and follow all permit provisions.
- Assess the potential for ground water contamination when using imazamox in turbid or deep lakes where the chemical may not degrade quickly.
- Do not use in areas where there are rare submersed or floating plant species unless Ecology agrees to the mitigation plan.

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## Evaluation of bispyribac-sodium

*Bispyribac-sodium*: sodium, 2,6-bis [(4,6-dimethoxy-pyrimidin-2-yl)oxy] benzoate

### 1. Registration status

At the request of the Valent U.S.A Corporation, EPA registered bispyribac-sodium for use in rice fields in 2001, and later as a selective herbicide for post emergent control of various weeds in golf courses and turf grass and sod farms. In March, 2011, EPA registered Tradewind™ Aquatic Herbicide (section 3) for selective management of surface, submersed, and emergent aquatic weeds in lakes, marshes, ponds, reservoirs, drainage ditches, and non-irrigation canals with limited or no outflow. Washington has registered Tradewind™ Aquatic Herbicide.

### 2. Description

Bispyribac-sodium is a selective ALS inhibiting herbicide that controls emergent, floating, and submersed weeds. ALS is a plant enzyme that regulates the production of essential three-branched amino acids in plants (valine, leucine, and isoleucine). ALS is

the first enzyme in the biosynthetic pathway for these amino acids. ALS compounds inhibit the production of these amino acids by binding to the ALS enzyme. Animals do not use the same biochemical pathways as plants, which may be the reason why ALS herbicides exhibit low toxicity to animals. Bispyribac-sodium is a systemic herbicide with long-lasting residual control. Herbicidal selectivity is determined by adsorption and translocation, and differential metabolism in plant species. Sensitive plants adsorb bispyribac-sodium through the leaf surface and translocate it throughout the plant.

The aquatic formulation of bispyribac-sodium Tradewind™ Herbicide is an 80% a.i. soluble powder packaged in water-soluble packets that the applicator mixes with water to apply as a liquid formulation. Applicators may apply Tradewind™ Herbicide as a subsurface treatment, targeting submersed aquatic plants or as a surface application targeting floating and emergent plants. When treating floating or emergent vegetation, applicators must use an adjuvant.

*Typical aquatic use:* Applicators may use weighted trailing hoses to apply Tradewind™ Herbicide to slow moving or quiescent freshwater bodies where there is minimal or no outflow such as lakes, ponds, reservoirs, marshes, drainage ditches, and non-irrigation canals. They may also apply Tradewind™ Herbicide to the water surface using handguns and the product will adequately mix through the water column. The label prohibits application to flowing water (rivers and streams), intertidal, or estuarine areas.

For surface application by spray to control floating and emergent plants, the maximum application rate for aquatic use is two ounces of formulated product per acre for a single application and no more than eight ounces of product /acre/year with a 30-day reapplication interval.

For in-water treatments, applicators may need to apply split or multiple ("bump") applications to maintain herbicide concentrations at sufficient levels for optimum control. Typical application rates of bispyribac-sodium are 20-45 ppb water column concentration in an initial treatment with additional bump applications to maintain adequate water concentrations for 60 to 90 days. This application scenario is similar to the way that applicators currently apply fluridone products for Brazilian elodea (*Egeria densa*) or Eurasian watermilfoil (*Myriophyllum spicatum*) management. Another ALS herbicide, penoxsulam, has similar application requirements.

The maximum water concentration allowed per treatment is 45 ppb. The label prohibits treating within 14 days after the initial application and allows only four in-water treatments per year (180 ppb per annual growth season if applied in four equal applications of 45 ppb each). The label prohibits concentrations of more than 45 ppb in

the treated water from any application (from either the initial treatment or when retreating an area to maintain an effective water concentration).

The manufacturer, Valent, suggests applying at the higher end of the allowed treatment concentration when the weed biomass is heavy, when weeds are mature and forming surface mats, or when treating less susceptible plants. Valent also recommends using ELISA (Enzyme-Linked Immunosorbent Assay) analysis or other analytical methods to measure bispyribac-sodium water concentrations. These measurements will help determine if, and when it is necessary to make sequential applications, and prevent exceeding the maximum treatment concentration when reapplying in an already treated area.

Treatment with bispyribac-sodium generally produces visual herbicide symptoms within two weeks of treatment. These symptoms include cessation of growth, discoloration of plant tissue with some yellowing and reddening of leaves and stems, followed by necrosis and death of plants. Symptoms occur slowly and may take two months or longer to affect the target plants. The amount and rate of control depends on the plant species, their growth stage, growth rate, and the herbicide concentration and timing of the treatment. The manufacturer recommends applying Tradewind™ Herbicide in the spring when the plants are actively growing. The efficacy of subsurface applications may decrease if the applicator does not maintain the exposure for sufficient time. Circumstances that result in insufficient contact time may include rapid inflow of water into the treated area, and small spot or shoreline treatments within larger water bodies. The label does not recommend bispyribac-sodium for spot or shoreline treatments. Spot treatments are to areas five acres or less.

The label warns that as an ALS inhibitor, weed populations may contain or develop plants naturally resistant to bispyribac-sodium or other ALS inhibitor herbicides (e.g., penoxsulam, imazamox, imazapyr). Weed species with acquired resistance to ALS herbicides may eventually dominate the weed population if an applicator uses ALS herbicides repeatedly in the same area or in successive years as the primary method of control. The label recommends the following steps to delay herbicide resistance:

- Alternate herbicides used for aquatic weed control.
- Base herbicide use on a comprehensive integrated pest management (IPM) program.
- Monitor treated weed populations for loss of efficacy to ALS herbicides.
- Contact aquatic plant experts or the manufacturer for advice about herbicide resistance management techniques.

### 3. Environmental and human health impacts

This section describes anticipated impacts of using bispyribac-sodium to control freshwater aquatic plants on the environment, aquatic biota, and human health. Ecology recommends mitigation measures, when appropriate. Applicators may use bispyribac-sodium at concentrations no greater than 45 ppb (maximum-labeled rate) for in-water treatments in ponds, lakes, reservoirs, marshes, drainage ditches, non-irrigation canals (slow-moving or quiescent bodies of water). Applicators may apply no more than two ounces per acre of the formulated aquatic product to floating and emergent plants. These concentrations of bispyribac-sodium pose negligible risk to the environment and non-target species based upon testing conducted by the registrant under EPA guidelines.

#### **Earth**

##### *Soils*

EPA concluded that bispyribac-sodium is a moderately persistent, and moderately to very mobile compound in most soils. The primary degradation pathways in soil and aquatic environments are aerobic and anaerobic metabolism with the formation of multiple major metabolites. Bispyribac-sodium residues further degrade in soil, eventually mineralizing to carbon dioxide.

Ecology expects no impacts to soils from the application of bispyribac-sodium products to water bodies in Washington State because there should be minimal exposure. Ecology does not anticipate drift onto soils through application to freshwater submersed, floating, or emergent plants. Information on the label, such as controlling droplet size, helps applicators control off-target drift when treating emergent or floating leaved vegetation using application equipment such as backpack sprayers or hoses. Applicators typically apply granular formulations (if a granular bispyribac-sodium product becomes available) from hand-held spreaders or spreaders mounted on boats and apply liquid formulations through subsurface hoses for submersed plant treatment.

Applicators must follow all mixing and loading procedures found on herbicide labels to prevent spills on unprotected soil. In the event of a spill, applicators must follow spill response procedures outlined in Ecology's water quality permit.

##### *Sediment*

In EPA-acceptable field studies in Arkansas and Louisiana, bispyribac-sodium dissipated in each study with a half-life of 11 days in the sediment (0-4 cm) and was only detected at low levels in the water (study done for registration in rice). Health Canada's risk assessment concluded that bispyribac-sodium would be moderately persistent in aquatic systems, although it partitions primarily to the water phase and it is not expected to accumulate in sediments.

## **Air**

The vapor pressure of bispyribac-sodium is  $1 \times 10^{-7}$  Hg @ 25° C. This vapor pressure and Henry's law constant of bispyribac-sodium indicate that it is non-volatile in the environment. Therefore, bispyribac-sodium residues are not expected in the air. The MSDS for Tradewind™ Aquatic Herbicide indicates some respiratory irritation may occur to exposure to high concentrations. As such, the applicator would be at highest risk through handling the concentrated material. However, exposure to the concentrate is unlikely to occur since the formulation is packaged in water-soluble packets.

Ecology expects any adverse impacts to air quality to bystanders from the application of bispyribac-sodium to be minimal and associated with a small amount of petroleum exhaust emissions related to the use of application equipment.

## **Water**

### *Surface water*

The solubility of bispyribac-sodium in water is 73,300 mg/L @ 25° C. It is highly water-soluble.

When applied directly to water, bispyribac-sodium is essentially stable to abiotic degradation by hydrolysis and aqueous photolysis. It is subject to microbial degradation under aerobic and anaerobic conditions. Researchers observed slower degradation in anaerobic aquatic environments (half-lives of 88-109 days) than in aerobic soil (half-life of 62 days). In aerobic aquatic environments, the half-life ranged from 46-82 days. In a field dissipation study in Florida, researchers applied 45 ppb bispyribac-sodium to water via subsurface injection and found a half-life of 25 days. At this site, bispyribac-sodium remained mainly in the water and was only detected once (3 days post-treatment at 5.9 ppb [parent plus a metabolite] in the sediment). The major metabolite (DesMe-2023) was present in the water at a maximum of 4.3 ppb (day 28) and dissipated with a half-life of 36 days.

These data, while limited, indicate that bispyribac-sodium seems unlikely to accumulate in sediments after aquatic plant treatments.

### *Dispersion*

*Submersed treatments:* Dispersion of bispyribac-sodium into non-treatment areas though in-water treatment may occur depending on many environmental factors including size of the treatment area, wind, circulation patterns, currents, inflows and outflows, etc. With larger scale treatments and long-term projects, it is very likely that bispyribac-sodium will disperse into areas where it is not intentionally applied. Because it is slow acting and needs a long contact time to be effective, the bispyribac-sodium label does not recommend its use for spot treatments.

Ecology will mitigate for the propensity for dispersion into untreated areas by conditioning its water quality permits to allow more limited treatment areas for nuisance weed control projects (similar to the amount of treatment allowed for fluridone).

*Emergent treatments:* Avoiding spray drift during treatment of emergent plants is dependent on the applicator. The applicator must select appropriate application equipment and treat only when environmental conditions (wind speed, temperatures) allow for effective treatment conditions. The label provides treatment mitigations to reduce spray drift. It is a violation of the FIFRA label and the NPDES permit for an applicator to not follow the label.

#### *Ground water*

Bispyribac-sodium is very soluble and EPA concluded that it is moderately to highly mobile in soils. In 2009, California added bispyribac-sodium to its Ground Water Protection List that identifies *registered agricultural use pesticides that have the potential to pollute California's ground water due to their chemical characteristics and intended uses*. California now monitors for bispyribac-sodium in ground water. However, given the low use rates and no drinking water restrictions, Ecology does not anticipate any adverse impacts to ground water from bispyribac-sodium aquatic use.

#### *Public water supply*

EPA identified no drinking water, swimming, or fish consumption restrictions for aquatic uses of bispyribac-sodium. Therefore, treatment using bispyribac-sodium should not have any impacts on public water supply or water use. There are irrigation and livestock watering restrictions (see Water, Land, and Shoreline use section).

## **Plants**

#### *Aquatic plants*

As expected for an herbicide, bispyribac-sodium is toxic to plants. Floating and emergent weeds listed as being controlled on the Tradewind™ label include duckweed (*Lemna* spp.), mosquito fern (*Azolla caroliniana*), parrotfeather (*Myriophyllum aquaticum*), and other species (species not present in Washington so they are not listed here). Submersed species include Hydrilla (*Hydrilla verticillata*), Eurasian watermilfoil (*Myriophyllum spicatum*), and sago pondweed (*Stuckenia pectinata*). Haller (2011) reported that bispyribac-sodium provided hydrilla control at less than 40 ppb. Because this active ingredient is new to the aquatics market (2011), it is likely that users will identify other susceptible species as this product receives wider use.

#### *Algae*

The registrant conducted studies to determine the toxicity of the formulated bispyribac-sodium product to a freshwater cyanobacterium (*Anabaena flos-aquae*), a freshwater diatom (*Navicula pelliculosa*), and a marine diatom (*Skeletonema costatum*). EPA reported that no statistically significant reductions in cell density (no toxicity) were

observed for any of the three species at the maximum concentration tested (1.0-1.1 mg a.i./L). An acceptable EPA study done on freshwater green algae (*Pseudokirchneriella subcapitata*) determined an 96-h EC<sub>50</sub> of 0.25 mg a.i./L based on cell density with a NOAEC of 0.031 mg a.i./L. Therefore, it is unlikely that use of bispyribac-sodium will have any effect on algae or algal populations. The manufacturer identified the macro algae *Chara* as being resistant to bispyribac-sodium.

#### *Non-target plants*

EPA did not anticipate any impacts to terrestrial plants so long as the applicator follows label requirements; spray drift should not occur with subsurface herbicide injections or emergent plant treatments.

#### **Animals**

Below is a summary table of toxicity endpoints for non-target aquatic organisms determined during EPA-approved toxicity testing during the registration process for bispyribac-sodium.

**Table 5 – Toxicity to non-target organisms for bispyribac-sodium**

<b>Freshwater Organism Studies</b>			
<b>Study</b>	<b>Organism</b>	<b>Results</b>	<b>Comments</b>
Fish acute LC <sub>50</sub>	Bluegill	>102 mg a.i./L	No mortality or sub lethal effects noted.
Fish acute LC <sub>50</sub>	Rainbow Trout	>102 mg a.i./L	No mortality or sub lethal effects noted.
Invertebrate Acute EC <sub>50</sub>	<i>Daphnia magna</i>	> 99.2 mg a.i./L	5% mortality at highest treatment level.
Fish Chronic NOAEC	Fathead Minnow	9.2 mg a.i./L	Only one concentration tested with no effects noted.
Invertebrate Chronic NOAEC	<i>Daphnia magna</i>	110 mg a.i./L	No mortality or sub lethal effects noted.
<b>Avian Studies</b>			
Avian Acute LD <sub>50</sub>	Bobwhite Quail	>2,250 mg/kg/bw	No mortality or sub lethal effects noted.
Avian Sub-acute LC <sub>50</sub>	Bobwhite Quail	>5,620 mg/kg-diet	No mortality or sub lethal effects noted.
Avian Sub-acute LC <sub>50</sub>	Mallard Duck	>5,620 mg/kg-diet	No mortality or sub lethal effects noted.
Avian Chronic NOAEC	Bobwhite Quail	1,000 mg/kg-diet	No mortality or sub lethal effects noted.
Avian Chronic NOAEC	Mallard Duck	1,000 mg/kg-diet	No mortality or sub lethal effects noted.
<b>Marine Organism Studies</b>			
Fish Acute LC <sub>50</sub>	Sheepshead Minnow	> 120 mg a.i./L	No mortality or sub lethal effects noted.
Invertebrates acute EC <sub>50</sub>	Eastern Oyster	> 110 mg a.i./L	Endpoint was shell deposition
Invertebrate acute EC <sub>50</sub>	Mysid shrimp	> 130 mg a.i./L	No mortality or sub lethal effects noted.

*Birds*

According to studies conducted by the manufacturer during the registration process, EPA classified bispyribac-sodium as practically non-toxic to avian species on an acute and sub-chronic oral basis. Avian reproduction studies using mallard ducks and bobwhite quail resulted in NOEACs of 1000 mg a.i. kg-diet for both species. EPA reported that the studies did not show any significant adverse effects on body weight, feed consumption, survival, or reproduction at the highest concentration of bispyribac-sodium tested. Based on these studies, Ecology does not anticipate any direct impacts to birds from the use of bispyribac-sodium in the aquatic environment.

### *Fish*

EPA classified bispyribac-sodium as practically non-toxic on an acute basis to freshwater fish. EPA based this conclusion on acute studies on rainbow trout and bluegill sunfish. EPA classified bispyribac-sodium as practically non-toxic to estuarine/marine fish based on acute studies of marine fish. There were no chronic studies done for marine species. However, bispyribac-sodium is not labeled for use in the marine/estuarine environment so there should be no-to-minimal exposure to marine organisms. EPA established a tolerance for freshwater fish for bispyribac-sodium at 0.01 ppm.

### *Invertebrates*

Bispyribac-sodium has an LD<sub>50</sub> of > 25 µg bee with no mortality or sub lethal effects noted in the study. This was the highest dose tested. The LC<sub>50</sub> for earthworms is > 1,000 ppm with no mortality or sub lethal effects noted. This was the highest dose tested.

EPA classified bispyribac-sodium as practically non-toxic to freshwater invertebrates (based on acute and chronic exposure studies for daphnids). Ecology expects no adverse impacts to either terrestrial or freshwater invertebrates from the aquatic use of bispyribac-sodium.

### *Threatened and endangered species*

EPA in its EFED concluded that the use of bispyribac-sodium to control aquatic weeds has the potential for direct adverse effects on threatened and endangered aquatic plants. EPA did not expect any direct adverse effects to aquatic animals (fish, aquatic-phase amphibians, and aquatic invertebrates) from acute or chronic exposure to bispyribac-sodium, although it concluded that there is a potential for indirect effects to listed aquatic animals. Listed species could be potentially affected indirectly due to alternations in their habitat such as food sources, shelter, and nesting areas by an herbicide.

Ecology mitigates indirect effects of herbicide use by requiring timing or consultation with WDFW when applicators use herbicides in water bodies with priority species. Ecology's permit manager consults the Natural Heritage Program database for priority habitats, plants, and animals before issuing permit coverage. The permit manager also checks WDFW timing windows for any restrictions. If applicable to the water body, Ecology coordinates mitigation efforts with the permit applicant, WDFW, and others, if appropriate to ensure adequate protections from in-water herbicide use. Because of the low toxicities and use rates for bispyribac-sodium, Ecology does not plan to impose treatment timing for salmon, bull trout, or steelhead in its water quality permits, but timing windows for other priority species will remain in effect. This could change should research indicate any sub-lethal impacts on fish related to bispyribac-sodium use.

Washington has several rare wetland and aquatic plants. Perhaps the biggest environmental impact from the use of bispyribac-sodium is the potential to affect rare floating or submersed plant species. To ensure protections, applicators may only legally

apply bispyribac-sodium for in-water treatments under water quality permits that make provision for mitigations for rare plants. Before issuing permit coverage, Ecology's permit manager consults the Natural Heritage Program database to determine the presence of any aquatic rare plants. If present, the manager works with the applicant to select appropriate mitigation measure to protect the rare species. This may include prohibiting the use of bispyribac-sodium, if warranted. Ecology's permit manager may issue an administrative order to further condition permit coverage.

### Water, land, and shoreline use

There are no label restrictions for drinking water, swimming, fishing, or fish consumption.

#### Humans

Below is a summary table of toxicity endpoints determined during EPA-approved toxicity testing during the registration process for bispyribac-sodium. These organisms are surrogates for humans.

**Table 6 – Acute toxicity studies for bispyribac-sodium**

Acute Toxicity for Bispyribac-sodium (Technical)			
Study	Organism	Results	EPA Toxicity Category
Acute LD <sub>50</sub>	rat	3,565 mg a.i./kg-bw	No effects at the highest treatment level tested.
Chronic NOAEC	rat	1000 mg a.i./kg-bw	LOAEC = 10,000 mg a.i. diet
Acute dermal LD <sub>50</sub>	rabbit	>2000 mg/kg	III
Acute dermal sensitization	guinea pig	Not a skin sensitizer	
Primary dermal irritation	rabbit	Not an irritant	IV
Primary eye irritation	rabbit	Moderate irritant (unwashed) Not an irritant (washed)	III IV
Sub-chronic Effects			
21-28 day dermal	rat	NOAEL = 1000 mg/kg/day LOAEL = 600 mg/kg/day	
90-day feeding study	dog	NOAEL = 100 mg/kg/day LOAEL = 600 mg/kg/day	
Chronic Effects			
There was no evidence that bispyribac-sodium is genotoxic, carcinogenic, or teratogenic. It is not a reproductive toxicant. There was no evidence of increased susceptibility of the offspring in the reproductive or developmental toxicity studies (Health Canada).			
Toxicity for Tradewind™ Aquatic Herbicide (from MSDS)			
Study	Organism	Results	EPA Category
Oral LD <sub>50</sub>	Rats	4,111 mg/kg (males) 2,635 mg/kg (females)	III

Dermal LD <sub>50</sub>	Rabbits, Rats	>2,000	III
Inhalation LC <sub>50</sub>	Rats	>4.48 mg/L	IV
Eye Irritation	Rabbits	Moderately irritating	III
Skin Irritation	Rabbits	Non-irritating	IV
Skin Sensitization	Guinea pigs	Non-sensitizing	

EPA concluded in its 2011 pesticide tolerance document (<http://edocket.access.gpo.gov/2011/2011-2266.htm>) that bispyribac-sodium was negative for carcinogenicity in feeding studies in rats and mice and classified it as a “not likely human carcinogen”. Mutagenicity studies conducted with the parent and three major metabolites were negative. There was no evidence of fetal toxicity or offspring susceptibility in the developmental toxicity studies in rats and rabbits or in the reproductive toxicity study in rats. EPA found that bispyribac-sodium showed no indications of central or peripheral nervous system toxicity in any study and that it did not appear to be structurally related to any other chemical that causes adverse nervous system effects.

EPA registered bispyribac-sodium for uses that could result in short-term residential exposure and EPA determined that it was appropriate to aggregate chronic exposure through food and water with short-term residential exposure. EPA concluded that the combined short-term food, water, and residential exposures result in aggregate margins of exposure ( MOE’s ) of 25,000 for the U.S. general population, 26,000 for adults 50 + years old, and 7,700 for all infants (< one year old). Because EPA’s level of concern for bispyribac-sodium is a MOE of 100 or below, these MOEs are not of concern. Their short-term aggregate assessment is protective of intermediate-term exposures to bispyribac-sodium. Based on their risk assessments, EPA concluded that there is a reasonable certainty that no harm will result to the general population or to infants and children from aggregate exposure to bispyribac-sodium residues. In short- and long-term toxicity studies on laboratory animals, target organs included the liver, bile duct, and gall bladder.

EPA established an oral reference dose of 0.1 mg/kg/day for bispyribac-sodium based on a NOEL of 10 mg/kg/day from the chronic feeding study in dogs and an uncertainty factor of 100.

Tradewind™ Aquatic Herbicide MSDA may cause brief and minor eye irritation that may include redness and swelling. However, the label does not require the applicators to wear eye protection when handling the undiluted product. The product may cause redness and some minor swelling to the skin. The label requires applicators to wear long-sleeved shirts and pants, shoes and socks, and chemical resistant gloves. EPA estimated that the

MOEs for pesticide handlers are greater than  $5.2 \times 10^5$  and therefore do not exceed the level of concern (100)

#### *Navigation*

Ecology expects treatment of areas of dense aquatic vegetation to improve navigation by creating areas of open water. Increased areas of open water may improve other recreational activities such as water skiing and boating in the treated water body.

#### *Swimming*

There are no swimming restrictions for bispyribac-sodium on the Tradewind™ Herbicide label. Ecology expects that treatment will improve swimming conditions when applicators use bispyribac-sodium to remove dense plants populations in areas use for swimming. Given the low use rates and low mammalian toxicity, Ecology sees no reason to recommend a 24-hour swimming advisory after treatment. Removal of aquatic vegetation from a designated swimming area may improve swimmers safety and allow lifeguards and parents better visibility should a swimmer experience difficulties.

#### *Fishing*

There are no fishing restrictions or fish consumption restrictions for bispyribac-sodium on the Tradewind™ Herbicide label. However, removal of aquatic vegetation, particularly during any whole-lake treatments may influence fish use patterns and fishers may need to alter fishing strategies to be successful. Negative effects on warm water fisheries have been reported (anecdotal, Kathy Hamel) after whole lake fluridone treatments when much of the submersed vegetation was removed. Prey species lose hiding places and are vulnerable to species such as bass. Some fisheries biologists have reported a loss of sunfish species (also non-native species in Washington) after whole lake herbicide treatments for noxious weed eradication.

#### *Agriculture*

Irrigation with bispyribac-sodium treated water may result in injury to irrigated vegetation. The Tradewind™ Herbicide label advises people to not use treated water to irrigate food or ornamental crops until the concentration of bispyribac-sodium is  $\leq 1$  ppb. People cannot use treated water as a water source for livestock until the concentration of bispyribac-sodium in water is  $\leq 1$  ppb.

## **4. Mitigation**

- Follow current label requirements.
- Use state-licensed applicators.
- Where required, apply bispyribac-sodium under Ecology water quality permits and follow all permit provisions.
- Do not use in areas where there are rare submersed or floating plant species unless Ecology agrees to the mitigation plan.

## 5. References

EPA 2010. Ecological Risk Assessment for Bispyribac Sodium Section 3 - New Use as an Aquatic Herbicide.

EPA 2001. Bispyribac-sodium In/On Rice. Health Effects Division (HED) Risk Assessment. <http://www.epa.gov/pesticides/chemical/foia/cleared-reviews/reviews/078906/078906-002.pdf>

Glomski, L. M., and C. R. Mudge. 2009. *Effect of submersed applications of bispyribac-sodium on non-target emergent vegetation*. APCR Technical Notes Collection (ERDC/TN APCR-CC-12). Vicksburg, MS: U.S. Army Engineer Research and Development Center. <http://ed.erd.usace.army.mil/aqua/>

Haller, W.T. 2011. In Invasive Plant Management Research and Outreach Newsletter. Volume 3, Number 1.

Health Canada. 2008. Proposed Registration Decision: Bispyribac-sodium. [http://www.hc-sc.gc.ca/cps-spc/pest/part/consultations/\\_prd2008-02/index-eng.php#what](http://www.hc-sc.gc.ca/cps-spc/pest/part/consultations/_prd2008-02/index-eng.php#what)

Tradewind™ Aquatic Herbicide MSDS

Valent. 2011. Tradewind™ Aquatic Herbicide Specimen Label

## Evaluation of flumioxazin

*Flumioxazin*: 2-[7-fluoro-3,4-dihydro-3-oxo-4-(2-propynyl)-2H-1,4-benzoxazin-6-yl]-4,5,6,7-tetrahydro-1H-isoindole-1,3(2H)-dione; an herbicide of the N-phenylphthalimide class.

### 1. Registration status

At the request of the Valent U.S.A. Corporation, EPA conditionally registered a terrestrial formulation of flumioxazin in 2001 for weed control in crops (peanuts, soybeans, and sites to be planted with cotton, field corn, rice, sorghum, sugarcane, sunflowers, tobacco, or wheat). Flumioxazin is active against certain grasses, broadleaf plants, and sedges. EPA registered an aquatic formulation of flumioxazin called Clipper™ in 2011. Clipper™ is a water dispersible granular product. Water dispersible granules are intended for application by conventional spraying equipment after disintegration and dispersion in water. Water dispersible granules are essentially dustless. Products containing flumioxazin are registered in the USA, Canada, Argentina, Brazil, Paraguay, China, France, South Africa, Zimbabwe, Israel, Japan, and Australia. The Washington Department of Agriculture has registered Clipper™.

## 2. Description

Flumioxazin is a broad-spectrum contact herbicide and an algaecide effective on filamentous green algae such as *Pithophora* and *Cladophora*. Flumioxazin is a light-dependent peroxidizing herbicide that blocks chlorophyll biosynthesis. This results in a buildup of phototoxic porphyrins in plant tissues. Porphyrins accumulate in susceptible plants causing photosensitization, which leads to membrane peroxidation. The peroxidation of membrane lipids leads to irreversible damage of membrane function and structure. Susceptible plants turn necrotic and die shortly after exposure to sunlight. Injury symptoms may occur within one day after treatment. In its aquatic review, EPA concluded flumioxazin is short-lived and its potential to contaminate the environment is relatively low.

*Typical aquatic use:* Applicators may use flumioxazin to manage aquatic plants in drainage ditches, freshwater ponds, lakes, marshes, and reservoirs as long as these water bodies have limited or no outflow at the time of treatment. Flumioxazin is fast acting and is applied subsurface through weighted, trailing hoses to control submersed and floating vegetation at a use rate of 100-400 ppb with a maximum use rate of 400 ppb. Flumioxazin can also control floating and emergent plants growing on or above the water surface when applied directly onto the foliage of the plants. The maximum use rate for surface and aerial application is 0.3825 pounds active ingredient per acre.

According to the Clipper™ label, this product is most effective when applied to young, actively growing plants in waters with a pH less than 8.5. At higher pH, Clipper™ breaks down very rapidly and loses its effectiveness. The label recommends applying the product early in the morning when the water column pH tends to be lower. The manufacturer notes that flumioxazin is most efficacious applied earlier in the growing season when plants have limited biomass and there is high light penetration into the water column. The Clipper™ label allows applicators to retreat the same area up to six times in a year, but only at 28-day intervals.

Repeated use of flumioxazin can lead to domination of a waterbody with a weed population that is resistant to this herbicide. To delay or prevent herbicide resistance, the manufacturer recommends:

- Avoiding consecutive use of Clipper™ or other herbicides with a similar mode of action.
- Basing herbicide use on a comprehensive integrated pest management program.
- Monitoring treated plant populations for loss of efficacy to flumioxazin.

Although contact herbicides, like flumioxazin, tend to be more acutely toxic to aquatic organisms than systemic herbicides like ALS inhibitors penoxsulam, imazamox, and

bispyribac-sodium, one of the categories for a reduced risk herbicide takes into consideration the need for less toxic alternatives. There are few effective and less toxic algaecides available to Washingtonians. Ecology considers some algaecides, like copper sulfate and chelated copper complexes, too toxic to fish and aquatic invertebrates to allow their use under its Aquatic Plant and Algae Management Permit. Ecology limits other algaecides to very low concentrations (e.g., Hydrothol 191) to mitigate toxic impacts to fish. This restricts options for applicators managing algae problems in lakes. Flumioxazin provides a less toxic alternative to those algaecides for the management of filamentous green algae. Contact herbicides also tend to have a much shorter half-life in the environment than do systemic (but often less toxic) herbicides.

Flumioxazin produces breakdown products, but there is little information available about the flumioxazin degradates. When developing its risk assessments, EPA assumed the flumioxazin breakdown products were at least as toxic as the parent herbicide - flumioxazin.

### **3. Environmental and human health impacts**

This section describes anticipated impacts of using flumioxazin to control freshwater aquatic plants and filamentous green algae on the environment, aquatic biota, and human health. Ecology recommends mitigation measures, when appropriate. Applicators may use flumioxazin at concentrations no greater than the maximum-labeled rate in lakes, ponds, and reservoirs with no or limited outflow. These concentrations of flumioxazin pose negligible risk to the environment and non-target species based upon testing conducted by the registrant under EPA guidelines.

#### **Earth**

##### *Soils*

Flumioxazin has a 3.2 - 8.4 day half-life on soil (average 5.8 days). The aerobic soil metabolism studies required by EPA for pesticide registration noted a moderate rate of metabolism with a flumioxazin half-life of 11.9 - 17.5 days (average 14.7 days) depending on soil type. The anaerobic soil metabolism study with a saturated soil showed a flumioxazin half-life of less than one day (0.2 days). Terrestrial field dissipation of flumioxazin in loam and sandy soils ranged from 10-42 days. California EPA attributed the higher half-life to a lack of rainfall or irrigation during the sampling period. An analysis of flumioxazin for use on crops by Australian scientists concluded that flumioxazin presented a low risk to soil microflora at the Australian label use rate (for terrestrial crop use).

Ecology does not anticipate significant drift of flumioxazin onto soils through application to submersed, floating, or emergent plants, or filamentous algae. Therefore, Ecology expects no impacts to soils from the application of flumioxazin products to water bodies

in Washington State. The aquatic registered formulation is a water dispersible granular. Applicators dissolve the water dispersible granules in water and apply the product as a liquid formation. Applicators typically apply liquid formulations through subsurface hoses for submersed plant treatment. They apply as a broadcast spray when treating floating or emergent plants or filamentous algae. Information on the label, such as controlling droplet size, helps applicators control off-target drift onto soils and non-target vegetation when treating above-water emergent or floating leaved vegetation.

Applicators must follow all mixing and loading procedures found on herbicide labels to prevent spills on unprotected soil. In the event of a spill, applicators must follow spill response procedures outlined in the water quality permit, in the product's label, and in the MSDS for the product.

#### *Sediment*

The registrant conducted two small pond studies to determine the aquatic field dissipation of flumioxazin at an Iowa and a Florida site. Researchers applied 400 ppb, the maximum label rate, to the water. They collected water and sediment samples from each site at 0-2 hours, 12-14 hours, and at approximately 1, 3, 5, 7, 14, 28, 60, and 90 days post-treatment. Samplers collected pond water samples at three depths: surface (one foot below), mid-depth, and bottom (one foot off the bottom). They collected sediment samples to a depth of 10 cm. Study results from Iowa (reported below) showed that flumioxazin was detected in the pond water at a maximum mean concentration of 233 ppb (58% of the target rate) at 0-2 hours (surface), decreased to 135 ppb by 12-14 hours (surface), 121 ppb by Day 1 (surface), 46.6 ppb by Day 3 (mid depth), 24.6 ppb by Day 5 (bottom), and 15.6 ppb by Day 7 (bottom). Flumioxazin was last detected above the Limit of Quantification (LOQ) at 28 Days post treatment at the bottom depth. The study also tracked degradation products that were also last detected in the water at 28 days post treatment.

Flumioxazin was detected in the pond sediment at concentrations above the LOQ at two sampling intervals only, at a mean concentration of 25.4 ppb at 12-14 hours and 17.7 ppb at 1-Day post treatment. Samplers did not detect any degradation products in the pond sediment after 7 Days post-treatment.

#### **Air**

Ecology expects adverse impacts to air quality from the use of flumioxazin to be minimal and associated with a small amount of petroleum exhaust emissions related to the use of application equipment. Flumioxazin itself is relatively non-volatile. The Henry's Law Constant of flumioxazin is estimated as  $6.28 \times 10^{-7}$  atm-cu m/mole derived from its vapor pressure of  $2.41 \times 10^{-6}$  mm Hg. The MSDS indicates that Clipper™ may be slightly toxic when inhaled, although the data indicate that any inhalation risk is most

likely from particulates. The Clipper™ formulation of flumioxazin is a water dispersible granule that is essentially non-dusty. This should reduce or eliminate applicator or bystander exposure to any dust when handling Clipper™ granules. The MSDS recommends using the material only in well-ventilated areas.

## **Water**

### *Surface water*

Flumioxazin degrades rapidly in water. Dissipation occurs by a combination of hydrolysis, photolysis, and metabolism of the parent compound (see the sediment section for information about the degradation of flumioxazin in water in a pond study). The solubility of flumioxazin is 1079 mg/l at 25° C. Octanol/water partition coefficient is  $\log K_{ow} = 2.55$  at 20° C. Low  $K_{ow}$  values (under 10) indicate lower bioconcentration factors for aquatic life.

Hydrolysis half-life:

- 4.2 days at pH 5
- 1 day at pH 7
- 0.01 day at pH 9

Photolysis in water: 1 day at pH 5.

Typically in lakes and ponds, the epilimnion pH during the spring/summer months ranges between 7.5 and 8.5, although during algae blooms or in dense plant beds, the pH can be as high as 10. Historical data collected under Washington's now defunct volunteer lakes monitoring program, indicates that most Washington lakes have summer pH values in this range. Based on typical summer pH values and higher spring/summer light conditions, Ecology expects flumioxazin to have a very short half-life in most Washington water bodies.

Flumioxazin is a rapidly acting contact herbicide. Contact herbicides affect the foliage of susceptible plants in the water column, but generally do not affect the roots. Contact herbicides can cause a rapid break down and decomposition of plant tissue that can lead to a loss of oxygen from the water. Oxygen depletion may cause fish kills. The Clipper™ label helps prevent these conditions by requiring that the applicator treat dense floating surface plants in sections. This limits the amount of biomass decomposing in any one area. The label restricts treatment to half the water body and applicators must wait for 10-14 days before treating the remaining area. The label also restricts retreatment of the same section of the water within 28 days of application.

Ecology's pesticide permits also prohibit any treatment that causes a fish kill. The applicator must evaluate environmental conditions and only treat if he or she determines that a fish kill is highly unlikely to occur. If controlling nuisance plants, Ecology's water

quality permit further limits the amount of littoral zone an applicator can treat in a water body.

The manufacturer advises treating early in the season. Early season treatment can help mitigate low oxygen conditions from developing after treatments. Water temperatures are cooler in the spring and cooler water holds more oxygen. Plant biomass is less in the spring so treating then reduces the amount of decomposing plant tissue. Decomposing tissue uses oxygen.

Treating aquatic plants with flumioxazin may increase phosphorus water concentrations as plants decompose. Because phosphorus is often the limiting nutrient for algal growth, increased phosphorus concentrations may lead to phytoplankton blooms in the water body. Residents often report algal blooms following treatment with herbicides. Label mitigations such as treating early in the spring will help limit the amount of biomass decomposing at any one time, however, lake residents must expect phytoplankton blooms following treatment of aquatic plants with contact herbicides.

#### *Dispersion*

Although all herbicides disperse in the water, flumioxazin degrades rapidly so the potential for off-target movement is much less than for persistent herbicides. Applicators often use contact herbicides when spot treating areas, along shorelines, or in areas of high water dilution since these herbicides generally need short contact times with the target plants for effective treatment.

#### *Ground water*

EPA concluded that flumioxazin is relatively unstable and its potential to leach to groundwater is low. The potential for the degradation products APF and THPA to leach to groundwater is high due to their high persistence and mobility. However, California EPA did not identify pesticides containing flumioxazin as having the potential to pollute ground water. <http://www.cdpr.ca.gov/docs/legbills/calcode/040101.htm>. For a list of metabolites, see [www.epa.gov/pesticides/chem\\_search/cleared\\_reviews/csr\\_PC-129034\\_14-Aug-03\\_a.pdf](http://www.epa.gov/pesticides/chem_search/cleared_reviews/csr_PC-129034_14-Aug-03_a.pdf).

An Australian evaluation of flumioxazin for terrestrial use concluded that column-leaching studies showed that flumioxazin leached significantly in sandy soils. Their calculations indicated the flumioxazin is a transitional leacher in sandy soils, but an improbable leacher on silty loam and clay loam soils. However, the field studies in sandy soil clearly showed that there was no movement of flumioxazin to deeper soil profiles. The two pond studies also showed no flumioxazin or degradates detected in the sediment after 28 days.

### *Public water supply*

Ecology anticipates no adverse effects due to exposure to flumioxazin from aquatic treatments. There are no drinking water restrictions, swimming restrictions, or fishing/fish consumption restrictions on the Clipper™ label. Ecology's water quality permits make special provision to protect municipal and community water intakes if an herbicide treatment could potentially affect large numbers of the public. In these cases, the potentially affected water right holder must agree to the treatment before Ecology will issue permit coverage.

### **Plants**

#### *Aquatic plants*

As expected for an herbicide, flumioxazin is highly toxic to plants, although as a contact herbicide, flumioxazin kills only the parts of the susceptible plants that it touches (water column foliage). Plants with viable roots in the sediment should regrow. Flumioxazin controls aquatic plants such as fanwort (*Cabomba caroliniana*), watermeal (*Wolffia* spp.), duckweed (*Lemna* spp.), pondweeds (*Potamogeton* spp.), Eurasian watermilfoil (*Myriophyllum spicatum*), and variable-leaf milfoil (*Myriophyllum heterophyllum*). It also controls some species of filamentous green algae.

In his PhD dissertation, Mudge (2007) reported on work by Frankart et al. (2002), that flumioxazin at 1, 10, and 50 ppb decreased photosynthetic capacity of *Lemna minor* by 23, 62, and 64% respectively.

Haller (2011) reported that flumioxazin produces greater than 60 % biomass reduction in hydrilla at 100 ppb and at pH 7.

Fanwort, a Class B noxious weed in Washington, is notoriously difficult to control with herbicides, but Valent reported excellent control using flumioxazin during a research trial in Indiana. Their contractor treated an 11-acre canal in July 2008 at a rate of 200 ppb Clipper™ (half the maximum label rate) and achieved 100% control of fanwort (as well as duckweed and watermeal) within three weeks of a subsurface application. In another trial, Valent reported nearly 100% success in eliminating nuisance watermeal populations from several small ponds using a rate of 200 ppb Clipper™. The applicator noted that Clipper™ removed the watermeal, but left desirable native plants behind.

Richardson, et al. (2008) conducted two greenhouse trials to compare the response of foliar applications of flumioxazin and carfentrazone-ethyl to emergent aquatic plants including a couple of species listed as noxious weeds in Washington (parrotfeather – *Myriophyllum aquaticum* and water primrose – *Ludwigia hexapetala*). Carfentrazone-ethyl and flumioxazin are both contact herbicides with similar modes of action. The authors reported that flumioxazin controlled alligatorweed, giant salvinia, and water lettuce in the greenhouse and suppressed water primrose and parrotfeather at rates of 34

to 437 g/hectare. They observed that an increased flumioxazin rate above 168 g/hectare did not result in increased control.

**Table 7 - Flumioxazin 70% and 90% effective concentration calculated from non-linear regression curves - From Richardson et al. (2008)**

Plant	EC <sub>70</sub>	EC <sub>90</sub>
Alligatorweed	22.8	35.6
Water primrose	120.0	*
Giant salvinia	256.0	*
Parrotfeather	164.0	*
Water lettuce	23.9	70.3

\* Authors report that the regression curve did not extend to 90% control level

### Algae

The Clipper™ label claims efficacy for filamentous green algae such as *Pithophora* and *Cladophora* when applied as a broadcast spray. Clipper™ can provide a less toxic alternative to using the monosalt of endothal (Hydrothol 191) when treating filamentous green algae in Washington lakes.

### Animals

When EPA evaluated flumioxazin for terrestrial use, it concluded that it is unlikely that flumioxazin will pose a risk of acute or chronic toxicity to non-target animals. Flumioxazin does not bioconcentrate through the food chain.

**Table 8 - Toxicity to non-target aquatic organisms for flumioxazin**

Freshwater Organism Studies			
Study	Organism	Results	EPA Toxicity Category
Fish 96 hour LC <sub>50</sub>	Bluegill	>21 mg a.i./l	Slightly toxic
Fish 96 hour LC <sub>50</sub>	Rainbow Trout	>2.3 mg a.i./l	Moderately toxic
Invertebrate 48 hour EC <sub>50</sub>	<i>Daphnia magna</i>	17 mg a.i./l	Slightly toxic
Avian Studies			
Avian 8 day dietary LC <sub>50</sub>	Mallard Duck	>5620 mg/kg	Relatively non-toxic
Avian 8 day dietary LC <sub>50</sub>	Bobwhite Quail	>5620 mg/kg	Relatively non-toxic
Marine Organism Studies			
Crustacean 96 hour LC <sub>50</sub>	Mysid Shrimp	0.23 mg a.i./l	Highly toxic
Algae 120 hour EC <sub>50</sub>	<i>Skeletonema costatum</i>		

### *Birds*

According to studies conducted by the manufacturer during the registration process, flumioxazin is practically non-toxic to birds. Flumioxazin is practically non-toxic to the bobwhite quail on an acute basis and practically non-toxic to the mallard duck and bobwhite quail on a sub-acute basis. In longer-term studies, a NOEL for reproductive effects (effects on egg production) in mallards was reported as 250 ppm. In bobwhite quails, the NOEL for reproductive effects was >500 ppm flumioxazin. The EPA estimated chance of individual mortality for birds following exposure to flumioxazin treatment is 1 in  $2.94 \times 10^5$ . Given the low toxicity to birds, low use rates, and rapid removal from the water column, Ecology does not believe that flumioxazin poses a risk to waterfowl or other birds when used according to the aquatic label.

### *Mammals*

Acute toxicity studies show that flumioxazin is practically non-toxic to rats both by the oral and dermal routes. In chronic studies (90 day oral study), the Lowest Observed Adverse Effect Level (LOAEL) values ranged from 197 to 244 mg/kg/day based on changes in blood parameters. An oral rat study of developmental effects reported a LOAEL of 10 mg/kg/day based on cardiovascular effects in offspring of rats treated during pregnancy. Reproductive effects such as reduced numbers of live born pups and smaller weight pups were reported in rodents at similar doses (15 mg/kg/d). Chronic toxicity tests in rodents also reported adverse health effects in kidney and blood parameters at similar doses (18 mg/kg/d).

Flumioxazin does not bioaccumulate in mammals. Studies showed that rats excrete flumioxazin in urine and feces, with 97% cleared in seven days. Given a low acute toxicity to mammals, low use rates, no bioaccumulation, and rapid removal from the water column, Ecology does not believe that flumioxazin poses a risk to mammals when used according to the aquatic label. The EPA estimated chance of individual mortality for small mammals following acute exposure to flumioxazin treatment is 1 in  $2.94 \times 10^5$ .

### *Fish*

Based on toxicity testing results, EPA considers flumioxazin slightly-to-moderately toxic to freshwater fish. EPA calculated an estimated chance of individual mortality following exposure to flumioxazin as 1 in  $1 \times 10^{16}$  for freshwater fish. The low use rates and non-persistence in the water limits the potential exposure of fish to flumioxazin when treating aquatic plants and algae. Therefore, Ecology does not believe that flumioxazin poses a risk to freshwater fish. However, Ecology recommends that applicators follow WDFW timing windows to protect priority fish species (see the threatened and endangered species section). Because the application work windows for anadromous fish generally start in July, this could limit the use of flumioxazin in salmon-bearing lakes since the registrant encourages early season use of this herbicide. The EPA tolerance for flumioxazin in freshwater fish is 1.5 ppm.

Flumioxazin is moderately toxic to highly toxic to estuarine/marine organisms. However, EPA does not allow any estuarine or marine use for flumioxazin and the Clipper™ label limits its use in freshwater to water bodies with limited or no outflow during treatments. Therefore, Ecology concluded that there was little risk to marine fish from freshwater treatments using flumioxazin because there is little chance of exposure.

#### *Invertebrates*

The LD<sub>50</sub> for honeybees for flumioxazin is >105 µg bee which EPA considers practically non-toxic. Earthworms were relatively insensitive to flumioxazin with the 14-day LC<sub>50</sub> > 948 mg/kg soil. Flumioxazin is moderately toxic to freshwater invertebrates (the 48-hour EC<sub>50</sub> for *Daphnia pulex* is 5.5 ppm). The EPA estimated chance of individual mortality following exposure to flumioxazin is 1 in 4.17 x 10<sup>8</sup> for freshwater invertebrates. In addition, the low use rates and low persistence in the environment, limits the potential exposure of freshwater invertebrates to this herbicide. Therefore, Ecology does not believe that flumioxazin use poses a high risk to freshwater invertebrates.

Flumioxazin is moderately to highly toxic to marine/estuarine invertebrates. The Clipper™ label does not allow treatment in marine or estuarine environments and limits treatments to water bodies where there is limited or no outflow after treatment. Therefore, Ecology does not believe that there is any risk to marine invertebrates from freshwater treatments of flumioxazin because there is little chance of exposure.

#### *Threatened and endangered species*

Washington has a number of rare wetland and aquatic plants. EPA concluded that for a single aquatic application, acute rare plant species levels of concern were exceeded at the maximum application rate of flumioxazin. In Washington, typically applicators may only legally apply flumioxazin under water quality permits that provide mitigations for herbicide treatment when rare plants are present. Before issuing permit coverage, Ecology's permit manager consults the Natural Heritage Program database to determine the presence of any aquatic rare plants. If present, the applicant generally hires a botanist to survey the water body. The permit manager consults with the Natural Heritage Program botanist, and the applicant to select appropriate mitigation measures to protect the rare plant populations. The permit manager may also request that Ecology's Aquatic Weeds Program botanist survey the lake before and after treatment. For some rare plant species, flumioxazin may not be an appropriate herbicide choice. In these cases, Ecology will work with the applicant to select a more appropriate herbicide or recommend a non-chemical management method.

EPA reported that the levels of concern for flumioxazin for freshwater fish and invertebrates were exceeded. Ecology mitigates impacts to threatened and endangered animals species and WDFW priority species by requiring applicators to comply with timing windows. These windows either do not allow herbicide treatment or allow

treatment at times when the herbicide will not affect the priority species or its food and habitat. As a mitigation measure to protect Washington’s priority animals and habitats, Ecology will require the applicators to follow WDFW timing windows for flumioxazin treatments in its water quality permits.

**Water, land, and shoreline use**

There are no label restrictions for using treated water for drinking, swimming, or fishing. EPA calculated the risk for drinking water consumption based on a maximum use rate of 400 ppb in the water column, applied at pH 7, applied six times per year, at the maximum application interval. This is a conservative approach and based on typical use patterns of treatments in Washington lakes, Ecology expects less treatment per lake than the EPA calculation.

*Humans*

**Table 9 - Toxicity studies for flumioxazin**

<b>Acute Toxicity</b>			
<b>Study</b>	<b>Organism</b>	<b>Results</b>	<b>EPA Toxicity Category</b>
Acute oral toxicity	rat	>5000 mg/kg	IV
Acute inhalation	rat	>0.069 mg/l	III
Acute dermal	rabbit	>2000 mg/kg	III
Acute dermal sensitization	guinea pig	Not a sensitizer	
Primary dermal irritation	rabbit	Non irritating	IV
Primary eye irritation	rabbit	No corneal irritation; mild irritation of iris cleared by 24 hours; mild irritation of conjunctiva cleared by 48 hours	III
<b>Sub-chronic Effects</b>			
Prenatal developmental (in utero exposure)	rat	NOAEL = 3 mg/kg/day LOAEL = 10 mg/kg/day based on cardiovascular effects, especially ventricular septal defects	
Reproduction and fertility effects	rat	NOAEL males = 6.3 mg/kg/day females = 7.6 mg/kg/day LOAEL males = 12.7 mg/kg/day females = 15.1 mg/kg/day based on a decrease in the number of live born and a decrease in pup body	
Chronic toxicity/carcinogenicity	rat	NOAEL males = 1.8 mg/kg/day females = 2.2 mg/kg/day LOAEL males = 18.0 mg/kg/day females = 21.8 mg/kg/day based on increased chronic nephropathy in males and decreased hematological parameters in females (Hgb, MCV, MCH, and MCHC). No evidence of carcinogenicity.	
<b>Chronic Effects</b>			

Tests indicate no evidence of oncogenicity. Flumioxazin was not mutagenic or genotoxic.

California EPA concluded that flumioxazin is low in acute mammalian toxicity and is safer for pesticide applicators to handle compared to many other contact herbicides (their conclusions are based on terrestrial registration of flumioxazin). Based on mammalian toxicity information, flumioxazin is less toxic than the other two contact aquatic herbicides used in Washington.

EPA classified flumioxazin as a “not likely” human carcinogen. EPA based their conclusion on the lack of carcinogenicity in a two-year rat study, an 18-month mouse study, and a battery of mutagenic studies. Flumioxazin did not induce significant increases in any tumor in either rats or mice under the study conditions. It did not induce any mutagenic activity in the required battery of mutagenicity studies.

There is increased susceptibility of rats (but not rabbits) to *in utero* and postnatal exposure to flumioxazin. Effects of flumioxazin following sub-chronic exposures at high doses included anemia, and increases in liver, spleen, heart, kidney, and thyroid weights. In dogs, high doses also produced effects. Washington State Department of Health believes that based on available data, flumioxazin may be an endocrine disrupting compound in mammals. Effects that may be associated with endocrine disruption were an increased incidence of reproductive organ abnormalities in rats (predominately atrophied or hypoplastic testes and or epididymides). These effects occurred at an LOAEL of 200 ppm (NOAEL = 100 ppm). Expected environmental concentrations after an aquatic treatment (maximum estimated concentration = 0.4 ppm) are below the NOAEL. Nevertheless, it is unknown if other endocrine related effects at these low concentrations may or may not occur or if the degradates will produce endocrine disrupting effects ([www.epa.gov/pesticides/chem\\_search/cleared\\_reviews/csr\\_PC-129034\\_14-Aug-03\\_a.pdf](http://www.epa.gov/pesticides/chem_search/cleared_reviews/csr_PC-129034_14-Aug-03_a.pdf)).

EPA calculated an oral reference dose (RfD) for flumioxazin of 0.02 mg/kg/bw/day based on the NOEL of 2.2 mg/kg/day for hematological and kidney changes in a chronic feeding/oncogenicity study in rates and an uncertainty factor of 100.

EPA concluded that the combined short-term food, water, and residential exposures to flumioxazin can result in a MOE of 690 for adults and 470 for children (*Flumioxazin Human Health Risk Assessment for a Proposed Aquatic Use*). Because EPA's level of concern for flumioxazin is a MOE of 100 or below, these MOEs are not of concern. EPA concluded that intermediate aggregate risks are identical to the short-term aggregate risks, since endpoints for short-term and intermediate-term risk assessments are the same, and because residential exposure durations are expected to be short-term in nature. Based on

their risk assessments, EPA concluded that there is a reasonable certainty that no harm will result to the general population and to infants and children from aggregate exposure to flumioxazin residues.

#### *Navigation*

Ecology expects treatment of areas of dense aquatic vegetation to improve navigation by creating areas of open water. Increased areas of open water may improve other recreational activities such as water skiing and boating in the treated water body.

#### *Swimming*

There are no swimming restrictions for flumioxazin on the aquatic label. In its human health risk assessment, EPA concluded that flumioxazin has little or no toxicity with respect to eye or skin irritation and it is not a dermal sensitizer. EPA assessed exposure and risk for recreational swimmers and considered their exposure estimates reasonable high-end estimates. Swimmer assessments based on EPA's proposed use pattern indicated that all MOEs are above the level of concern with MOEs ranging from 2,300 (children oral exposure) to 84,000 (adult dermal exposure). MOEs of 100 or less are of concern. Ecology expects removal of aquatic vegetation in public swimming areas to improve swimming conditions and swimmer safety.

#### *Fishing*

There are no fishing restrictions for flumioxazin in treated waters and no fish consumption restrictions. Residues of flumioxazin and its degradates were determined in the water and in edible fish tissues (bluegill and channel catfish) over a 28-day period of exposure at two times the maximum aquatic application rate (800 ppb). Total flumioxazin fish tissue residues were highest at the earliest sampling interval (four hours) and ranged from 0.85 - 2.52 ppm. Total residues declined rapidly by Day 3 and then remained relatively steady up to Day 28 (0.063-0.204 ppm). Total flumioxazin residues did not bioaccumulate in the fish over the 28-day study. EPA established a 1.5 ppm tolerance for residues in freshwater fish.

#### *Agriculture*

Irrigation with flumioxazin treated water may result in injury to irrigated vegetation. The label prohibits using treated water for irrigation until at least five days after application. Treatment with flumioxazin may affect individuals with legal water rights or claims for irrigation water. However, Ecology's water quality permit mitigates for the possible loss of this benefit by allowing project proponents to provide an alternative water supply to affected parties during the five-day irrigation restriction.

#### **Data gaps**

There are several major degradates of flumioxazin and there is little information to describe the fate of these degradates in the environment. Although the toxicities of the major degradates are unknown, EPA is not requiring toxicity studies at this time due to the risk quotients indicating low concern. EPA assumed the same toxicity for the degradates as for the parent chemical, but EPA did not characterize the toxicity of the

degradates. EPA noted in the EFED *that the registrant is conducting two terrestrial field dissipation studies and will submit these studies to EPA.*

Flumioxazin is a phytotoxic herbicide. EPA concluded that light dependent peroxidizing herbicides maybe more toxic to animals when organisms are exposed to natural sunlight as occurs in freshwater treatments. Since toxicity studies are normally conducted under relatively low artificial light, in 2001 EFED recommended a fish phototoxicity study for light-dependent peroxidizing herbicides. To Ecology's knowledge, the registrant has not completed this study at the time that it published this document.

EPA did not select flumioxazin for the first batch of chemicals to be screened for endocrine disruption. This was likely because the potential for human exposure is not high. No new data is expected soon.

#### **4. Mitigation**

- Follow current label requirements.
- Use state-licensed applicators.
- Apply during WDFW work windows in salmon-bearing waters.
- Where required, apply flumioxazin under Ecology water quality permits and follow all permit provisions.
- Do not use in areas where there are rare submersed or floating plant species unless Ecology agrees to the mitigation plan.

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## Evaluation of carfentrazone-ethyl

Ethyl a,2-dichloro-5-[4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl]-4-fluorobenzenepropanoate

### 1. Registration status

The FMS Corporation received conditional Section 3 registration for carfentrazone-ethyl products from the EPA in 1998 for broadleaf weed control on cereal grain groups and

soybeans. EPA subsequently registered carfentrazone-ethyl for use on turf and ornamental sites. In 2004, EPA registered carfentrazone-ethyl as Stingray™ aquatic herbicide for use in fresh water bodies. Carfentrazone-ethyl is a member of the Aryl triazolinone chemical family and typical use rates for this chemical are considered extremely low. EPA classified Stingray™ as a reduced risk pesticide. FMS submitted the toxicity, ecotoxicity, and environmental fate studies pertaining to carfentrazone-ethyl to Ecology to support the registration of this herbicide and the development of this EIS. Stingray™ has been registered in Washington.

## 2. Description

Carfentrazone-ethyl is a rapid-acting, light dependent, contact herbicide that inhibits the enzyme protoporphyrinogen oxidase (commonly abbreviated as protox). In plants, inhibition of the protox enzyme induces the formation of peroxides that attack the lipids and proteins of the cell membrane. This disruption causes leakage of cell contents, resulting in drying and disintegration of terrestrial plants within 24 to 48 hours. The process and onset of action of carfentrazone-ethyl is slower on aquatic plants than it is for terrestrial plants. Injury symptoms on susceptible aquatic plants generally include leaf bronzing and blackening and necrosis. Time to the appearance of the symptoms varies by plant species but is generally two to five days. Rapid destruction of the plant tissue results in self-limited translocation of the herbicide in the plant and subsequently limits the herbicide damage to the point of contact. Stingray™ exhibits selectivity to non-target grass species.

*Typical aquatic use:* Stingray™ is a liquid formulation that is emulsifiable in water. The maximum application rate is 13.5 fluid ounces per acre (0.2 lb a.i. per acre) per any single application or 200 ppb for submersed weeds (Stingray™ label). State licensed applicators may use Stingray™ in ponds, lakes, reservoirs, marshes, wetlands, drainage ditches, canals (non-irrigation), streams, rivers, and other slow-moving or quiescent bodies of water. They may apply the product as a broadcast spray to floating or emergent vegetation (with a surfactant), or via subsurface injection for submersed species. The manufacturer claims that Stingray™ is rainfast within one hour, although the label warns applicators to avoid wash-off of the chemical by boaters or rain. Applicators may also draw down the water and treat the vegetation in the drawn down area within one day of the draw down. When applying in flowing water, applicators must treat when traveling upstream to prevent above-label concentration of the herbicide in the water. Carfentrazone-ethyl requires light for activity with the herbicide symptoms appearing rapidly at the point of contact.

The Stingray™ label allows the applicator to treat up to a maximum of one-half of the water body at one time, with a minimum of 14 days before retreatment or treatment of the remaining half of the waterbody. Stingray™ performs best when the target plants are

young and actively growing. Using muddy or dirty water when preparing spray solutions can reduce herbicidal activity. The manufacturer claims no systemic activity for Stingray™. Contact herbicides affect the plant parts directly in contact with the herbicide. Because carfentrazone-ethyl is a contact herbicide, plants with roots in the sediment will regrow.

### **3. Environmental and human health impacts**

This section describes anticipated impacts of using carfentrazone-ethyl and its major metabolite carfentrazone-ethyl chloropropionic acid to control freshwater aquatic plants on the environment, aquatic biota, and human health. Ecology recommends mitigation measures, when appropriate. Applicators may use carfentrazone-ethyl at concentrations no greater than 200 ppb (maximum-labeled rate) in ponds, lakes, reservoirs, marshes, wetlands, drainage ditches, canals (non-irrigation), streams, rivers, and other slow-moving or quiescent bodies of water. These concentrations of carfentrazone-ethyl pose negligible risk to the environment and non-target species based upon testing conducted by the registrant under EPA guidelines.

#### **Earth**

##### *Soils*

Carfentrazone-ethyl is rapidly degraded in soil ( $DT_{50} < 1.5$  days) through microbial degradation, initially by hydrolysis to F8426-chloropropionic acid, and then through further side-chain degradation to other acids. The New York State Department of Environmental Conservation in their registration review of carfentrazone-ethyl concluded that although the four primary degradates of carfentrazone-ethyl are persistent, they are also much less toxic than carfentrazone-ethyl.

The half-life of carfentrazone-ethyl in aerobic soil is 1.3 days and in anaerobic soil 0.3 - 0.8 days. Based on results from field studies, investigators observed that carfentrazone-ethyl and its major metabolite F8426-chloropropionic acid were confined to the top soil layer, indicating only slight mobility in soil. Carfentrazone-ethyl was immobile in loamy sand, sandy clay loam, and silt loam soils and broke down rapidly in the soil. Terrestrial field dissipation was 2-5 days. Carfentrazone-ethyl is hydrolytically unstable in alkaline conditions (half-life of 5.1 hours), with stability increasing with decreasing pH.

Ecology does not anticipate significant drift of carfentrazone-ethyl onto soils from the treatment of submersed, floating, or emergent plants. Therefore, Ecology expects no impacts to soils from the application of carfentrazone-ethyl products to water bodies in Washington State. The aquatic registered formulation is a liquid that is emulsifiable in water. Applicators typically apply liquid formulations through subsurface hoses for submersed plant treatment. They apply as a broadcast spray when treating floating or emergent plants. Information on the label, such as controlling droplet size, helps

applicators control off-target drift onto soils and non-target vegetation when treating above-water emergent or floating leaved vegetation.

Applicators must follow all mixing and loading procedures found on herbicide labels to prevent spills on unprotected soil. In the event of a spill, applicators must follow spill response procedures outlined in the water quality permit, in the product's label, and in the MSDS for the product.

#### *Sediment*

Measured half-lives of carfentrazone-ethyl in flooded soil ranged from 6.5 hours to 1.5 days. In a Florida pond dissipation study, Koschnick, et al. (2004) found that carfentrazone-ethyl and its major metabolite degraded rapidly from the aquatic environment and did not accumulate in the sediment. They also observed that the degradation of carfentrazone-ethyl was highly influenced by pH.

#### **Air**

Ecology expects minimal adverse impacts to air quality from the use of carfentrazone-ethyl. These impacts are mainly from petroleum exhaust from application boats. EPA did not consider volatilization to be an important route of dissipation for carfentrazone-ethyl or its major degradate. The vapor pressure of carfentrazone-ethyl is  $1.2 \times 10^{-7}$  mm Hg at 25° C and  $5.4 \times 10^{-8}$  mm Hg at 20° C. There should be no significant loss from leaf surfaces following applications to floating leaved or emergent vegetation. Rapid herbicidal action at the leaf surface further reduces volatility potential. The MSDS indicates that Stingray™ has low inhalation toxicity.

#### **Water**

##### *Surface water*

The solubility of carfentrazone-ethyl in water is 12-30 ppm with solubility varying with pH. The major metabolite, chloropropionic acid, has high water solubility (approximately 1,500 ppm) and is very mobile in soil). Other major degradates of carfentrazone-ethyl are also very mobile.

Hydrolysis: Carfentrazone-ethyl is stable at pH 5, has a half-life of 8.6 days at pH 7, and a half-life of 3.6 hours at pH 9.

Photolysis: The aqueous half-life of carfentrazone-ethyl and carfentrazone-ethyl-chloropropionic acid is less than 8.3 days at pH 5.

The major routes of degradation of carfentrazone-ethyl in water are hydrolysis and photolysis. When applied to water, carfentrazone-ethyl hydrolyzes rapidly to the first major metabolite carfentrazone-ethyl-chloropropionic acid in a few hours. Carfentrazone-

ethyl and carfentrazone-ethyl-chloropropionic acid had a calculated half-life of 3.45 and 4.50 days in two separate pond dissipation studies in which investigators applied Stingray™ to half the pond. In both studies, investigators did not find carfentrazone-ethyl in sediment and only traces of carfentrazone-ethyl-chloropropionic acid were found in the sediment.

Typically in lakes and ponds, the epilimnion pH during the spring/summer months ranges between 7.5 and 8.5, although during algae blooms or in dense plant beds, the pH can be as high as 10. Historical data collected under Washington's now defunct volunteer lakes monitoring program, indicates that most Washington lakes have summer pH values in this range. Based on typical summer pH values, higher spring/summer light conditions, and a decreasing half-life in water as pH rises, Ecology expects carfentrazone-ethyl to have a very short half-life in most Washington water bodies.

Carfentrazone-ethyl is a rapidly acting contact herbicide. Contact herbicides affect the foliage of susceptible plants in the water column, but generally do not affect the roots. Contact herbicides can cause plants to drop out of the water column to the sediment within days of treatment. That can lead to the rapid break down and decomposition of plant tissue that can cause a loss of oxygen from the water. Oxygen depletion may lead to fish kills. The Stingray™ label helps prevent low oxygen conditions by restricting treatment to half the water body at one time. Applicators must wait a minimum of 14 days before retreating or treating the remaining area.

Ecology's pesticide permits also prohibit any treatment that causes a fish kill. The applicator must evaluate environmental conditions and only treat if he or she determines that a fish kill is highly unlikely to occur. If controlling nuisance plants, Ecology's water quality permit also limits the amount of littoral zone an applicator can treat in a water body. When treating submersed weeds like Eurasian watermilfoil, the manufacturer advises treating early in the growing season. Early treatment can mitigate low oxygen conditions developing after treatments. Water temperatures are cooler and cooler water holds more oxygen. There is less plant biomass early in the growing season and treating then reduces the amount of decomposing plant tissue.

Treatment with carfentrazone-ethyl may increase phosphorus concentrations in the water as plants decompose. Because phosphorus is often the limiting nutrient for algal growth, this may lead to increased phytoplankton blooms in the water body. Water body residents often report algal blooms following treatment with herbicides. However, the label mitigations will help limit the amount of biomass decomposing at any one time. If they chose to use herbicides, residents should expect to see increased algal blooms.

### *Dispersion*

Although all herbicides disperse in the water, carfentrazone-ethyl degrades very rapidly, particularly at the pH seen in Washington lakes. This means that the potential for off-target movement is less for carfentrazone-ethyl than for other chemistries that are more persistent. Applicators often use contact herbicides when spot treating areas, along shorelines, or in areas of high water dilution since contact herbicides generally only require short contact times with the target plants for effective treatment.

### *Ground water*

EPA concluded that carfentrazone-ethyl breaks down rapidly in the environment, although its degradates are more persistent in aquatic and terrestrial environments. Because of its low application rate, EPA anticipates carfentrazone-ethyl residues to occur at only low rates in groundwater. EPA does not expect these residues to trigger acute or chronic risk for non-target plants or animals. A Canadian risk assessment of carfentrazone-ethyl concluded that although laboratory studies indicate that carfentrazone-ethyl and its transformation products are mobile in soil, there is no field evidence that use of this herbicide will result in groundwater contamination. They thought that the biotransformation processes would offset any leaching through soil with a low potential for groundwater contamination.

### *Public water supply*

There are potable water restrictions. Applicators cannot apply Stingray™ within a quarter mile of an active potable water intake unless the water intake is turned off prior to and for a minimum of 24 hours after application. Water users may turn the water intake on before 24 hours if carfentrazone-ethyl and major degradate levels in the intake water are below 200 ppb as determined by a manufacturer-approved laboratory. Ecology's water quality permits make special provision to protect municipal and community water intakes if an herbicide treatment could potentially affect large numbers of the public. In these cases, the potentially affected water right holder must agree to the treatment before Ecology will issue permit coverage.

EPA determined that acute drinking water levels of concern are estimated at 175,000 mg/kg/day, surface water estimated environmental concentration at 21.4 ppb, and ground water estimated environmental concentration at 13.4 ppb for United States subpopulations. EPA estimated the chronic drinking water levels of concern at 998 mg/kg/day, the surface water estimated environmental concentration at 20.2 ppb and ground water at 13.4 ppb for U.S. subpopulations.

There is no swimming or fishing restriction, but there is one-day livestock watering restriction if 20 to 50% of the surface acreage of the water body is treated with Stingray™.

Irrigation with treated water may result in injury to vegetation. The Stingray™ label prohibits the use of treated water in commercial nurseries or greenhouses. There is a one-day irrigation restriction for crops when the treatment is equal or less than 20 percent of the surface area of the water body and a 14-day irrigation restriction when the treated area is 20% or more of the surface area. However, irrigation can resume when testing by a manufacturer-approved laboratory determines that the concentration of carfentrazone-ethyl and its major degradates is less than 5 ppb.

There is no irrigation restriction for commercial turf farms or for residential turf and ornamentals as long as the treated area is 20% or less of the surface area. If the treatment is larger, there is a 14-day irrigation restriction for these purposes.

Ecology's water quality permit mitigates for the possible loss of irrigation water rights by allowing project proponents to provide an alternative water supply to affected parties holding legal water rights while irrigation restrictions are imposed.

## **Plants**

### *Aquatic plants*

As expected for an herbicide, EPA found that carfentrazone-ethyl was toxic to both vascular and nonvascular aquatic plants. However, the Stingray™ label claims treatment efficacy for just few species. These include duckweed (*Lemna* spp.), mosquito fern (*Azolla caroliniana*), and watermeals (*Wolffia* spp.) (Species found in Washington).

Koschnick, et al. (2008) conducted efficacy trials on water hyacinth (*Eichcornia crassipes*), water lettuce (*Pistia stratiotes*), salvinia (*Salvinia minima*) and landoltia (*Landoltia punctata*). They found that carfentrazone-ethyl controlled water lettuce, water hyacinth, and salvinia at rates less than 225 g/hectare, with water lettuce being the most susceptible species.

Wersal et al. (2010) found a 64 and 65% reduction in parrotfeather biomass when they applied carfentrazone-ethyl at 0.20 mg a.i. /L during a dark and light exposure period. They hypothesized that having a dark exposure period might result in more herbicide damage with light-activated herbicides like carfentrazone-ethyl and flumioxazin. However, they found that the dark exposure did not result in increased efficacy of carfentrazone-ethyl against parrotfeather (or other tested plant species).

Glomski et al (2006) showed variable control of parrotfeather milfoil of 29 to 70% whereas Eurasian watermilfoil control was  $\leq 70\%$  in their studies. However, Wersal et al. in another study found that carfentrazone-ethyl was not efficacious against Eurasian watermilfoil. The biomass of their treated and control plants was statistically similar. This is in contrast to a study by Gray et al. (2006) that reported 100% reduction of Eurasian

watermilfoil biomass at 200 ppb a.i. carfentrazone-ethyl. Wersal et al. attribute their poor results in controlling milfoil to more alkaline pH in the water column that likely reduced the half-life of carfentrazone-ethyl in their treatments. This may have reduced the herbicide/plant contact time and resulted in no biomass reduction.

Richardson, et al. (2008) conducted two greenhouse trials to compare the response of foliar applications of carfentrazone-ethyl and flumioxazin to emergent aquatic plants including a two species listed as noxious weeds in Washington (parrotfeather - *Myriophyllum aquaticum* and water primrose - *Ludwigia hexapetala*). Carfentrazone-ethyl and flumioxazin are both contact herbicides with similar modes of action. The authors reported that carfentrazone-ethyl did not control alligatorweed, water primrose, or parrotfeather at the rates evaluated (56, 112, and 224 gram a.i./ hectare), although they speculated that higher rates could potentially provide control on alligatorweed. Richardson in unpublished data noted that carfentrazone-ethyl has been observed to have efficacy on variable-leaf milfoil (*Myriophyllum heterophyllum*) under North Carolina field conditions.

*Algae*

The Stingray™ label does not claim any efficacy for algae, but the label also includes a statement that says that the product is very toxic to certain species of algae. The EC<sub>50</sub> for four non-vascular species ranged from 6.5 ppb for a freshwater diatom to 17.2 ppb for green algae. Freshwater green algae were also exposed to three degradation products. The most toxic degradation product, F4826-chloropropionic acid, has an EC<sub>50</sub> of 26.2 ppb.

*Non-target plants*

**Animals**

EPA concluded that because carfentrazone-ethyl is practically nontoxic to birds, mammals, and beneficial insects, and because the EECs are low, it expects minimal risk to animals from the use of carfentrazone ethyl as an aquatic herbicide.

**Table 10 - Toxicity to non-target aquatic organisms for carfentrazone-ethyl**

Freshwater Organism Studies			
Study	Organism	Results	Comments
Fish 96 hour LC <sub>50</sub>	Bluegill	2.0 mg/L	Moderately Toxic
Fish 96 hour LC <sub>50</sub>	Rainbow Trout	1.6 mg/L	Moderately Toxic
Invertebrate 48 hour EC <sub>50</sub>	<i>Daphnia magna</i>	>9.8 mg/L <sup>3</sup>	Moderately Toxic
Avian Studies			
Avian dietary LC <sub>50</sub>	Mallard Duck	>5620	Relatively Non-toxic

<sup>3</sup> Maximum attainable concentration due to water solubility.

Avian dietary LC <sub>50</sub>	Bobwhite Quail	>5620	Relatively Non-toxic
<b>Marine Organism Studies</b>			
Crustacean 96 hour LC <sub>50</sub>	Mysid Shrimp	1.17 mg/L	Moderately Toxic
Mollusk 96 hour LC <sub>50</sub>	Eastern Oyster	2.3 mg/L	Moderately Toxic
Algae EC <sub>50</sub>	<i>Skeletonema costatum</i>	13.3 µg/L	

### *Birds*

According to studies conducted by the manufacturer during the registration process, carfentrazone-ethyl is practically non-toxic to birds on an acute and a subacute basis. The acute oral LD<sub>50</sub> is >2,250 mg/kg in bobwhite quail, and the subacute dietary LC<sub>50</sub> is >5,620 mg/kg in bobwhite quail and the mallard duck. Investigators did not observe any mortality at any dose level. In bobwhite quail and mallard reproduction studies there were no mortalities or effects on any reproductive parameters up 1000 ppm. There were adverse effects on growth of bobwhite at 1000 ppm (NOAEC = 167 ppm).

### *Mammals*

In mammals, inhibition of the enzyme protoporphyrinogen oxidase interferes with the heme biosynthetic pathway. Long-term dosing studies show that this results in alterations in hematological profiles and/or increased urinary porphyrin levels and hepatotoxicity. EPA observed that relatively high doses of carfentrazone-ethyl (800 ppb for males; 200 ppm for females) caused damage to liver cells in rats, but growth and reproduction were not impaired. Ecology does not expect any impacts to mammals from treatments of carfentrazone-ethyl. The maximum use rate in water is 200 ppb and its expected short half-life in water will lead to short exposure times to mammals.

### *Fish*

Carfentrazone-ethyl is moderately toxic to freshwater and estuarine fish. The toxicity of the carfentrazone-ethyl ranged from 1-2 ppm. EPA reported that toxicity testing of four carfentrazone-ethyl degradation products with rainbow trout, water flea, and mysid shrimp indicate that these degradation products are slightly toxic to practically nontoxic to aquatic animals.

EPA found that in an early life-stage study, carfentrazone-ethyl reduced fish growth at 242 ppb, with an NOAEC established at 118 ppb. However, because carfentrazone-ethyl belongs to a class of pesticides known to exhibit enhanced toxicity in the presence of sunlight, EPA also required an early life-stage study conducted under full spectrum lighting to simulate solar radiation. This study indicated that toxicity was enhanced in the presence of solar radiation with effects observed at the lowest test concentration of 16.4 ppb. However, EPA also noted that there were problems with this study (low oxygen levels, variable concentrations of carfentrazone-ethyl) and asked that registrant repeat the study. Ecology has not seen the results from the second study.

EPA determined that the acute risk LOC for any group of non-endangered freshwater aquatic organisms was not exceeded, even if retreatment with carfentrazone-ethyl was made in shallow waters. However, the chronic risk LOC to fish is exceeded for application of carfentrazone-ethyl to shallow waters. Given the low use rates and the short half-life of carfentrazone-ethyl expected in Washington waters, Ecology does not expect to see chronic effects on fish in waters treated with this herbicide.

#### *Invertebrates*

Carfentrazone-ethyl is practically nontoxic to honeybees and to earthworms. The LD<sub>50</sub> for bees is >200 µg/bee. The LC<sub>50</sub> for earthworms is >820 mg/kg. Carfentrazone-ethyl is slightly to moderately toxic to freshwater and estuarine invertebrates. Carfentrazone-ethyl is not registered for use in marine or estuarine environments and its use in freshwater should not have any impact on estuarine invertebrates because there should not be any exposure potential.

#### *Threatened and endangered species*

Washington has a number of rare wetland and aquatic plants. EPA did not calculate a risk quotient for nontarget aquatic plants. However, Ecology concluded that rare plant species were potentially at risk from the use of carfentrazone-ethyl. Typically applicators may only apply carfentrazone-ethyl legally under water quality permits that make provision for mitigations for rare plants. Before issuing permit coverage, Ecology's permit manager consults the Natural Heritage Program database to determine the presence of any aquatic rare plants. If present, the applicant generally hires a botanist to survey the water body. The permit manager consults with the Natural Heritage Program botanist, and the applicant to select appropriate mitigation measures to protect the rare plant populations. The permit manager may also request that Ecology's Aquatic Weeds Program botanist survey the lake before and after treatment. In some cases, carfentrazone-ethyl may not be an appropriate choice of herbicide.

EPA determined that the acute and chronic LOC for endangered freshwater fish inhabiting shallow waters is exceeded even with a single application of carfentrazone-ethyl. Ecology mitigates impacts to threatened and endangered animal species and WDFW priority species by requiring applicators to comply with timing windows. These windows either do not allow herbicide treatment or allow treatment at times when the herbicide will not affect the priority species or its food and habitat. As a mitigation measure to protect Washington's priority animals, Ecology will require the applicators to follow WDFW timing windows for carfentrazone-ethyl treatments. In some circumstances, Ecology may not allow treatment with carfentrazone-ethyl.

#### **Water, land, and shoreline use**

There are no label restrictions for using water treated with carfentrazone-ethyl for swimming or fishing and there are no restrictions on fish consumption from treated areas.

**Table 11 - Toxicity information for carfentrazone-ethyl**

<b>Acute Toxicity Studies for Carfentrazone-ethyl (Technical)</b>			
<b>Study</b>	<b>Organism</b>	<b>Results</b>	<b>EPA Toxicity Category</b>
Acute oral toxicity LD <sub>50</sub>	rat	>5,000 mg/kg	IV
Acute inhalation LC <sub>50</sub>	rat	>5.09 mg/L	III
Acute dermal LD <sub>50</sub>	rat	>4,000 mg/kg	IV
Acute dermal sensitization	guinea pig	Not a sensitizer	
Primary dermal irritation	rabbit	Non-irritant	IV
Primary eye irritation	rabbit	Minimal eye irritant	III
<b>Subchronic Effects</b>			
90-day subchronic feeding study	rat	NOAEL males = 226 mg/kg/day females = 284 mg/kg/day LOAEL males = 470 mg/kg/day females = 578 mg/kg/day based on decreases in body weight, reductions in food consumption, and histopathological lesions.	
90-day subchronic feeding study	mouse	NOEL = 571 mg/kg/day LOAEL = 1143 mg/kg/day based on findings in the liver pathology.	
90-day subchronic feeding study	dog	NOEL = 50 mg/kg/day LOAEL = 150 mg/kg/day based on systemic toxicity (decrease in the rate of weight gain in females and an increase in porphyrin levels in both sexes.	
Two-generation reproduction dietary study	rat	Established a parental NOEL for systemic and reproductive/developmental parameters of 127 mg/kg/day for males and 142 mg/kg/day for females.  The parental LOEL for systemic and reproductive development Parameters was 343 mg/kg/day for males and 387 mg/kg/day for females.  There was no systemic toxicity demonstrated at dose levels of ≤ 1500 ppm. There were no treatment-related clinical signs of toxicity or increases in mortality at any dose levels.  The offspring NOEL was 142 mg/kg/day and the LOEL was 387 mg/kg/day. The NOEL for	

		reproductive toxicity was $\leq$ 387 mg/kg/day; the highest dose tested. There were no clinical signs of toxicity reported for the pups of either generation.	
<b>Chronic Effects</b>			
In studies with laboratory animals, carfentrazone-ethyl was not oncogenic, neurotoxic, or teratogenic and did not cause developmental or reproductive effects.			

Metabolism of carfentrazone-ethyl in rats was rapid and extensive and occurred through a variety of pathways involving hydrolysis of the ester moiety (see the Canadian risk assessment to see the metabolites of carfentrazone-ethyl). A metabolism study in rats indicated that approximately 72.4 to 87% of the administered dose of carfentrazone-ethyl was rapidly absorbed and excreted in the urine within 24 hours after dosing.

EPA did not formally evaluate the potential effects of carfentrazone-ethyl on the endocrine systems of animals. However, EPA found no evidence of such effects in the chronic or reproductive toxicology studies required for registration. There was no observed pathology of the organs associated with endocrine function in these studies and there is no evidence that carfentrazone-ethyl causes endocrine effects.

EPA established an acute dietary reference dose (RfD) for carfentrazone-ethyl of 5 mg/kg/day. EPA based this on an acute neurotoxicity study in rats with a threshold NOEL of 500 mg/kg/day and an uncertainty factor of 100. A reference dose is the estimate of the amount of chemical that a person can be exposed to on a daily basis that is not anticipated to cause adverse health effects over a person's lifetime. Canada did not require an acute RfD for carfentrazone-ethyl because it has low acute toxicity potential. EPA established a chronic dietary RfD for carfentrazone-ethyl of 0.03 mg/kg/day. EPA based this RfD on a two-year chronic toxicity/carcinogenicity study in rats with a threshold NOEL of 3 mg/kg/day and an uncertainty factor of 100.

The Hazard Identification Assessment Review Committee in the EPA (HIARC) determined that short- and intermediate-term dermal risks do not need to be assessed since investigators did not observe any systemic effects in a 21-day dermal study in the rat at dose levels up to 1000 mg/kg/day. Additionally, investigators did not observe any developmental effects in any of the available developmental studies.

EPA concluded that based on the completeness and reliability of the toxicity data and the conservative exposure assessment, there is a reasonable certainty that no harm to humans will result from aggregate exposure to residues of carfentrazone-ethyl, including all anticipated dietary exposure and all other non-occupational exposures. EPA may apply an additional safety factor for infants and children to account for prenatal and postnatal

toxicity and the completeness of the database. Based on the current toxicological data requirements, EPA concluded that this database is complete for carfentrazone-ethyl and an additional uncertainty factor for infants and children is not warranted. Therefore, EPA determined that the RfD of 0.03 mg/kg/day is appropriate for assessing aggregate risks to infants and children.

TOXNET did not consider that an acute exposure to carfentrazone-ethyl would pose any significant toxicological risk due to its effects on porphyrin metabolism. They speculate that a transient form of porphyria variegata may occur following a massive exposure or long-term exposure to lower rates. This is unlikely to occur through aquatic use since the use rates are low and the half-life in water, particularly at pH levels in Washington lakes, is very short.

#### *Navigation*

Ecology expects treatment of areas of dense aquatic vegetation to improve navigation by creating areas of open water. Increased areas of open water may improve other recreational activities such as water skiing and boating in the treated water body.

#### *Swimming*

There are no swimming restrictions for carfentrazone-ethyl on the aquatic label. Ecology expects removal of aquatic vegetation in public swimming areas to improve swimming conditions and swimmer safety.

In determining swimming exposure risks from carfentrazone-ethyl in treated lakes and ponds, HIARC determined that short- and intermediate-term dermal risks did not need to be assessed since no systemic effects were observed in a 21-day dermal study in the rat at dose levels up to 1000 mg/kg/day. Inhalation exposure during swimming is highly unlikely due to the high vapor pressure and the low concentrations of carfentrazone-ethyl expected in treated water. Therefore, the registrant only evaluated the oral route of exposure using the procedure that EPA used to evaluate swimming risk for another contact herbicide, diquat dibromide. Based on a water concentration of 150 ppb the MOE for adults is 957,488 and the MOE for children is 293,341. The MOE = acute oral NOAEL of 500 mg/kg/day. These estimates of exposure are a high-end estimate because people are not likely to swim in treated water immediately after treatment for five hours per day. In addition, the concentration of carfentrazone-ethyl will rapidly degrade in treated water.

#### *Fishing*

There are no fishing restrictions or fish consumption restrictions for carfentrazone-ethyl in treated waters. The use of carfentrazone-ethyl as an aquatic herbicide has the potential to enter the food chain by accumulation in fish and shellfish. The registrant evaluated the exposure of individuals from consumption of fish exposure to the herbicide from aquatic use using data from a fish bioaccumulation study in rainbow trout. In this study,

investigators exposed fish continuously to radioactive-labeled carfentrazone-ethyl concentrations of 16 or 160 ppb. The higher exposure level is similar to the EEC based on the use rate for the aquatic formulation. The study exposed fish continuously for 28 days in a flow-through system. Study concentrations in edible tissue reached 5.57 mg/L after 10 days, with much higher concentrations seen in non-edible tissues. During a depuration phase of the study, the investigators found that fish eliminated about 50% of the radioactivity within 24 hours. By day 14 of the depuration phase, fish eliminated 98.4 and 99.1% of the radioactivity. In a water body treated with carfentrazone-ethyl, an applicator treats once and carfentrazone-ethyl concentrations rapidly decline. The herbicide levels determined in the study fish provide a worst-case estimate compared to levels that could accumulate in fish during an actual treatment.

The registrant conducted a risk assessment using study levels and a model (DEEM™) for ingestion of fresh fish. The acute exposure to freshwater fish and shellfish in the diet of various population groups indicates a low level of exposure potential even when assuming that consumer eats the entire fish. All population groups showed an exposure below 1% of the acute PAD. The registrant believes that it is reasonable to conclude that the true acute exposure potential would be nominal. The chronic exposure estimates to freshwater fish also indicated a low level of exposure for most population groups.

Residues of carfentrazone-ethyl in bluegills, channel catfish, freshwater clams, and northern crayfish were determined at the maximum application rate of 0.3 pounds a.i. per surface acre. No parent herbicide was found in any of the edible tissues.

#### *Agriculture*

Irrigation with carfentrazone-ethyl treated water may result in injury to irrigated vegetation. Treatment with carfentrazone-ethyl may affect individuals with legal water rights or claims for irrigation water. However, Ecology's water quality permit mitigates for the possible loss of this benefit by allowing project proponents to provide an alternative water supply to affected parties during any irrigation restrictions.

#### **Data gaps**

There are several major degradates of carfentrazone-ethyl although they appear to be well characterized.

## **4. Mitigation**

- Follow current label requirements.
- Use state-licensed applicators.
- Apply during WDFW work windows in salmon-bearing waters.
- Where required, apply carfentrazone-ethyl under Ecology water quality permits and follow all permit provisions.

- Do not use in areas where there are rare submersed or floating plant species unless Ecology agrees to the mitigation plan.

## 5. References for carfentrazone-ethyl

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Stingray™ Aquatic Herbicide Label

Stingray™ MSDS

TOXNET Toxicology Data Network. Carfentrazone-ethyl <http://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+7253>

Wersal, R. M., J. D. Madsen, J. H. Massey. W. Robles, and J. C. Cheshier. 2010. *Comparison of Daytime and Night-time Applications of Diquat and Carfentrazone-ethyl for Control of Parrotfeather and Eurasian Watermilfoil*. J. Aquat. Plant Manage. 48:56-58.

# Appendices

## Appendix A. List of abbreviations

µg	Microgram(s)
° C	Degree(s) Celsius
a.i.	Active ingredient
RfD	Reference dose
bw	Body weight
d	Day(s)
DT <sub>50</sub>	Dissipation time to 50% (the dose required to observe a 50% decline in the test population)
EC <sub>50</sub>	Exposure concentration to 50% (a concentration causing 50% adverse effects in the test population)
EEC	Expected environmental concentration
Hg	Mercury
kg	Kilogram(s)
K <sub>ow</sub>	Octanol-water partition coefficient
LC <sub>50</sub>	Lethal concentration to 50% (a concentration causing 50% mortality in the test population)
LD <sub>50</sub>	Lethal dose to 50% (a dose causing 50% mortality in the test population)
L	Liter(s)
LOAEL	Lowest observed adverse effect level
LOC	Level of concern
LOD	Level of detection
LOQ	Level of quantitation
mg	Milligram(s)
MOE	Margin of exposure
NOAEL	No observed adverse effect level
NOEC	No observed effect concentration
NOEL	No observed effect level
pH	-log <sub>10</sub> hydrogen ion concentration
ppb	Parts per billion (µg/L)
ppm	Parts per million (mg/L)
RQ	Risk quotient

Risk Quotient: EPA calculates a risk quotient (RQ) by dividing a point estimate of exposure by a point estimate of effects. This ratio provides a simple, screening level estimate that identifies high- or low-risk situations. See [http://www.epa.gov/oppefed1/ecorisk\\_ders/toera\\_risk.htm](http://www.epa.gov/oppefed1/ecorisk_ders/toera_risk.htm) for a detailed explanation of RQ.

## Appendix B. EPA Ecotoxicological Categories

EPA Ecotoxicological categories for mammals, birds, and aquatic organisms

Acute Oral Toxicity in Mammals (mg/kg body wt)	Toxicity in Birds		Acute Toxicity in Fish and Invertebrates (mg/L test solution)	Toxicity Ranking
	Acute Oral (mg/kg body wt)	Dietary mg/kg feed)		
<10	<10	<50	<0.1	Very Highly Toxic
10-50	10-50	50-500	0.1-1.0	Highly Toxic
>50-100	>50-100	>50-1000	>1-10	Moderately Toxic
>500-2000	>500-2000	>1000-5000	>10-100	Slightly Toxic
>2000	>2000	>5000	>100	Practically Non-Toxic