ECOLOGICAL RISK ASSESSMENT OF WILDLAND FIRE-FIGHTING CHEMICALS: LONG-TERM FIRE RETARDANTS

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EXECUTIVE SUMMARY
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The U.S. Forest Service uses a variety of fire-fighting chemicals to aid in the suppression of fire in wildlands. These products can be categorized as long-term retardants, Class A foams, and water enhancers. This chemical toxicity risk assessment of the long-term retardants examined their potential impacts on terrestrial wildlife and aquatic species. Exposures from both planned and accidental releases were considered, including on-target drops to terrestrial areas, accidental or unavoidable drops across water bodies, and accidental spills to a stream during aerial or ground transport.

This risk assessment evaluates the toxicological effects associated with chemical exposure, that is, the direct effects of chemical toxicity, using methodologies established by the U.S. Environmental Protection Agency. A risk assessment is different from and is only one component of a comprehensive impact assessment of all types of possible effects from an action on wildlife and the environment, including aircraft noise, cumulative impacts, habitat effects, and other direct or indirect effects. Consultation under Section 7 of the *Endangered Species Act* and environmental assessments or environmental impact statements pursuant to the *National Environmental Policy Act* consider chemical toxicity as well as other potential effects to make management decisions.

Each long-term retardant product used in wildland fire-fighting is a mixture of individual chemicals. The product is supplied as a concentrate, in either a liquid or powder form, which is then diluted with water to produce the mixture that is applied during fire-fighting operations. The risk assessment process for a product had a two-part approach: (1) toxicity data on the whole product were considered, to account for any effects due to the product being a mixture (synergism or antagonism); and (2) each and every ingredient in the product formulations was screened, and risk from any ingredient with higher toxicity was separately quantified.

The results presented in this risk assessment depend on a number of factors, including the availability of relevant scientific information, standard risk assessment practices, exposure assumptions, and toxicity dose-response assumptions. Whenever possible, this risk assessment integrated chemical- and species-specific scientific information on the response of aquatic and terrestrial organisms as well as the vegetative community. The approaches used to address these factors introduce minor to significant amounts of uncertainty into the risk assessment's conclusions; this assessment identifies the types of uncertainty affecting this analysis and estimates the degree to which they may affect the conclusions reached. Overall, when assumptions were required, a conservative approach was taken, to provide risk results that are protective of the environment.

Summary of Estimated Risks to Terrestrial Wildlife from Long-Term Retardants

- The retardant salt in four retardant products was predicted to pose a risk to small sensitive omnivores when applied at rates of 2 gpc and greater, to sensitive raptors when applied at 4 gpc and greater, and to sensitive songbirds when applied at 3 gpc and greater.

- The mixtures of individual ingredients in seven products were predicted to present an additive risk to some sensitive species.
- All retardant products posed a risk to some sensitive terrestrial animals at certain rates of application when evaluated based on the toxicity data for the formulated product as a whole. In most cases, these risks were consistent with or less than those predicted for the product based on evaluation of individual or additive risks from its ingredients.

Summary of Estimated Risks to Aquatic Wildlife from Long-Term Retardants

- No risks of acute toxic effects were predicted for aquatic wildlife in streams receiving runoff from land where retardant was applied to fuels (vegetation) at any coverage level (application rate) during fire-fighting activities.
- Three retardants salts and two pigment ingredients present in multiple products were predicted to pose risks to sensitive aquatic species at one or more coverage levels (application rates) in the case of an accidental or unavoidable application of retardant across a small stream. All retardant products present risk to one or more sensitive aquatic species if applied across a small stream.
- All concentrated and mixed retardants were associated with risk to one or more aquatic species if spilled into a small or large stream at the volumes assumed in risk assessment.
- Two products (Phos-Chek 259-Fx and Phos-Chek LCE20-Fx) may pose risks of sublethal effects from long-term exposures to ammonia for bivalves based on very conservative (unlikely to underestimate) assumptions about the amount of un-ionized ammonia present.
- For freshwater mussels, runoff from retardant-treated areas is not expected to result in water concentrations that would pose a risk. However, for mussels and other aquatic species, an accidental spill of concentrated or mixed retardant (particularly in a small stream) would likely result in mortality.

Summary of Risk Evaluation for Plant Species

- Few studies have evaluated the potential effects of fire retardants on terrestrial vegetation. Overall, they indicate the possibility of phytotoxic effects to individual plants of more sensitive species at the application rates typically used, but generate no expectation of widespread or enduring impacts.
- The phytotoxic effects and vegetation diversity endpoints in this analysis have underlying links related to mechanisms of toxicity (for example, varying susceptibility to effects on seed germination among plant species). However, further exhaustive or quantitative analysis of the topic is not warranted, since only limited areas are treated with these products and the vegetation would otherwise be severely affected by the fire itself in the absence of their use.

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Acronyms and Abbreviations

EC_{50}	median effective concentration
EPA	Environmental Protection Agency
GLEAMS	Groundwater Loading Effects of Agricultural Management Systems
gpc	gallons per 100 square feet
kg	kilogram
L	liter
L/RMP	land / resource management plan
LC_{50}	median lethal concentration
LD_{50}	median lethal dose
LOEC	lowest effective concentration
mg	milligram
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
N	nitrogen
NH_3-N	nitrogen in the form of unionized ammonia
NH_4^+	nitrogen in the form of ionized ammonium
NOEC	no observed effect concentration
ppm	parts per million
QPL	Qualified Products List
spp.	multiple species
U.S.	United States
USDA	U.S. Department of Agriculture

ECOLOGICAL RISK ASSESSMENT OF WILDLAND FIRE-FIGHTING CHEMICALS: LONG-TERM FIRE RETARDANTS

1.0 INTRODUCTION

The United States (U.S.) Forest Service uses a variety of fire-fighting chemicals to aid in the suppression of fire in wildlands. These products can be categorized as long-term retardants, foams, and water enhancers. The potential ecological impacts of the products were first assessed in a programmatic risk assessment prepared in 1994. The risk assessments have been periodically updated to include new products and assessment approaches, most recently in 2007. This report provides a new structure for maintaining the product-specific risk assessments that will ease reference, access, and organization of the most current information for each product.

This risk assessment analyzes the ecological risks due to chemical toxicity from using long-term retardants in wildland fire-fighting. A companion report evaluates the risks to human health from retardant use. Separate risk assessments address human health and ecological risks from Class A foams and water enhancers.

This risk assessment evaluates the toxicological effects associated with chemical exposure, that is, the direct effects of chemical toxicity, using methodologies established by the U.S. Environmental Protection Agency. A risk assessment is different from and is only one component of a comprehensive impact assessment of all types of possible effects from an action on wildlife and the environment, including aircraft noise, cumulative impacts, habitat effects, and other direct or indirect effects. Consultation under Section 7 of the *Endangered Species Act*[1] and environmental assessments or environmental impact statements[2] pursuant to the *National Environmental Policy Act* consider chemical toxicity as well as other potential effects to make management decisions.

The risk assessment methodology that was employed for assessing the ecological risks from wildland fire retardants is detailed in the main section of this document. The main document also includes a concise discussion and summary of risk conclusions for the products in use. Product-specific analyses are separate attachments to this document, allowing for assessments of newly qualified retardant products to be developed and attached, without revision of the entire report and all contents. Updates within this main document would be contained in any future revision to the "Current Risk Summary" subsection of Section 4.

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[1] In 2011, the U.S. Fish and Wildlife Service and National Marine Fisheries Service issued biological opinions concluding that fire retardants applied aerially to Forest Service lands would not jeopardize the continued existence of proposed, threatened, or endangered species under their respective jurisdictions, nor adversely affect their critical habitat. Reasonable and prudent measures were specified to minimize, avoid, and mitigate incidental take.

[2] In 2011, the Forest Service authorized continued use of aerially applied fire retardants as the decision following an environmental impact statement and associated public participation for three alternative approaches to aerial retardant use.

This report is organized into five major sections. Section 1.0 provides an introduction, background information, and an overview of the analysis approach. Sections 2.0 through 4.0 are organized according to the steps in the ecological risk assessment process (see Section 1.2 for an overview of each step). Section 5.0 lists the references cited throughout this report. The attachments present the product-specific detailed risk assessments.

1.1 Background: Fire-Fighting Chemicals

The information in the following paragraphs was derived from the Forest Service's Wildland Fire Chemicals Systems information web site (USFS 2020):

- *Long-term fire retardants*, commonly referred to as retardants, are applied from aerial or ground equipment. The red liquids dropped from aircraft, often viewed in media coverage of wildland fire-fighting activities, are retardants. These products, which are primarily the same salts found in fertilizers, are supplied as either wet or dry concentrates. They are mixed with water in a prescribed ratio and are applied to a target area just ahead of a fire (during wildland firefighting) or prior to a fire (during prescribed fire operations). While the water contained in the mixed product aids in firefighting, its primary purpose is to aid in accurately delivering the product to the fire. They continue to be effective after the water in the mixture has evaporated, as the fertilizer salt residue slows the spread and reduces the intensity of fire.

- *Class A Foam fire suppressants*, commonly referred to as foams, are supplied as liquid concentrates similar to liquid dishwashing products that are mixed with water and then aerated to produce foam. They are applied from aerial or ground equipment directly to the fire area to slow or stop combustion. Foam bubbles and their components (water and the concentrated product in it) interact with fuel surfaces in several ways. The fuels may absorb the moisture as it drains out of the foam mixture, which makes them less susceptible to combustion, and may be protected from wind, heat, and flame by foam coating the fuel's surface. Depending on the desired outcome, a wide range of foam characteristics can be prepared from the same concentrate by changing the mix ratio and adjusting the foam generation and application method used. Higher amounts of concentrate and aeration in the foam solution produce drier, slow draining foam for vertical surface protection. Moderate amounts produce wetting, fast draining foam for vegetation (horizontal surface) application. Low amounts can be used to make "wet water" that has enhanced penetration for mop up.

- *Water enhancers,* commonly referred to as gels, are supplied as liquid or dry concentrates that contain thickeners and other ingredients that, when mixed with water, improve aerial application, minimize drift, and aid in adherence to fuels. Water enhancers may be applied from ground or aerial application equipment. These products may be used in structure protection within the wildland interface or on wildland fuels. The effectiveness of water enhancers depends on the water content of the gels and, once they dry out, they are no longer effective.

Foams and water enhancers increase the inherent ability of water to suppress fire, while retardants leave a dried residue after the water evaporates that helps to protect the fuel from burning. Risk assessments for these product categories are being updated.

Fire-fighting chemicals may be dropped from fixed-wing airplanes ("airtankers") or helicopters, or applied by ground crews from fire engines or using portable equipment; the application methods approved for each product are listed on the current Qualified Products List (QPL).

1.2 Overview of Analysis

The purpose of this assessment is to estimate the potential ecological impacts as a result of the use of retardants in wildland fire-fighting. This ecological risk assessment looks only at the biological risks of the wildland fire-fighting chemicals, should they be used. It does not evaluate alternatives to their use, nor does it discuss factors affecting management decisions on whether chemicals should be used in a particular situation.

This ecological risk assessment follows the steps of problem formulation, analysis, and risk characterization, as described in the U.S. Environmental Protection Agency's (EPA's) *Guidelines for Ecological Risk Assessment* (EPA 1998). This risk assessment also identifies uncertainties that are associated with the conclusions of the risk characterization. The discussion that follows briefly describes these elements. A detailed description of ecological risk assessment methodology is contained in the EPA guidelines.

1.2.1 Problem Formulation

In problem formulation, the purpose of the assessment is provided, the problem is defined, and a plan for analyzing and characterizing risk is determined. The potential stressors (in this case, wildland fire-fighting chemicals), the ecological effects expected or observed, the receptors, and ecosystem(s) potentially affected are identified and characterized. Using this information, the three products of problem formulation are developed: (1) assessment endpoints that adequately reflect management goals and the ecosystem they represent, (2) conceptual models that describe key relationships between a stressor and assessment endpoint, and (3) an analysis plan that includes the design of the assessment, data needs, measures that will be used to evaluate risk hypotheses, and methods for conducting the analysis phase of the assessment.

1.2.2 Analysis

Analysis is a process that examines the two primary components of risk—exposure and effects—and the relationships between each other and ecosystem characteristics. The assessment endpoints and conceptual models developed during problem formulation provide the focus and structure for the analysis. Exposure characterization describes potential or actual contact or co-occurrence of stressors with receptors, to produce a summary exposure profile that identifies the receptor, describes the exposure pathway, and describes the intensity and extent of contact or co-occurrence. Ecological effects characterization consists of evaluating ecological effects (including ecotoxicity) data for the stressor of interest, as related to the assessment endpoints and the conceptual models, and preparing a stressor-response profile.

1.2.3 Risk Characterization

Risk characterization (1) uses the results of the analysis phase to develop an estimate of the risks to ecological entities, (2) describes the significance and likelihood of any predicted adverse effects, and (3) identifies uncertainties, assumptions, and qualifiers in the risk assessment.

2.0 PROBLEM FORMULATION

This section presents the results of the problem formulation, in which the purpose of the ecological risk assessment is provided, the problem is defined, and a plan for analyzing and characterizing risk is determined. As stated in Chapter 1, the purpose of this assessment is to estimate the potential ecological impacts as a result of the use of wildland fire chemicals such as long-term retardants.

2.1 Problem Definition: Integration of Available Information

In this first step of problem formulation, the risk assessment identifies and characterizes the stressors, the ecological effects expected or observed, the receptors, and ecosystem potentially affected.

2.1.1 Stressors

In this ecological risk assessment, the potential stressors are the retardants that may be used to fight fires. The retardants addressed in this risk assessment are those approved for use by the US Forest Service, as listed on the current QPL. Profile data for each product are summarized in Appendix A.

Each long-term retardant product used in wildland fire-fighting is a mixture of individual chemicals. The product is supplied as a concentrate, in either a liquid or powder form, that is then diluted with water to produce the mixture that is applied during fire-fighting operations. The risk assessment process for a product had a two-part approach: (1) toxicity data on the whole product were considered, to account for any effects due to the product being a mixture (synergism or antagonism); and (2) each and every ingredient in the product formulations was screened, and risk from any ingredient with toxicity exceeding a screening threshold (see Section 2.4.1) was separately quantified.

The application rate for retardants varies by situation; the type of fuel (vegetation) is a major factor in this determination. The application rates assumed in this risk assessment for retardants applied to various fuel types are included in Table 2-1 in Section 2.1.4. The application rates vary from 1 to 6 gallons of mixed (diluted) product per 100 square feet (gallons per 100 square feet, or “gpc”).

2.1.2 Ecological Effects

The ecological effects that may be caused by retardants are those associated with (1) direct toxicity to terrestrial wildlife and aquatic species that encounter the chemical, (2) phytotoxicity, and (3) effects on vegetation diversity. Permanent or persistent exposures through terrestrial environmental pathways are not expected, since the application “footprint” of these chemicals is quite limited in terms of foraging areas and species habitat for any individual animal, and the ingredients generally degrade in the environment. Although bioaccumulation was evaluated in simple predator-prey scenarios, the potential for long-term biomagnification in the terrestrial food web was not evaluated for this same reason. The potential for impacts from persistent aquatic exposure to ammonia from the retardant salts was evaluated, as some aquatic species could be limited to habitats, such as ponds, where exposure would be longer term. Effort is made to avoid or minimize application into waterways, including ponds; see discussion in Section 3.0 of the "Interagency Policy for Aerial and Ground Delivery of Wildland Fire Chemicals Near Waterways and Other Avoidance Areas."

Fire is an integral component to and may have beneficial impacts on ecosystems. Adverse effects to an ecosystem could occur in terms of a decrease in fire-based beneficial effects. However, these effects are not directly related to risks from the chemicals specifically, but are tied to fire management and suppression decision-making regarding all methods of fire suppression. An analysis of these risks and benefits is outside the scope of this risk assessment, which focuses only on potential ecological risks from the retardants; however, a subset of related risk management considerations is briefly discussed in Section 4.4.

2.1.3 Receptors

The potential receptors in this ecological risk assessment were selected to represent a range of species present in wildlands. These receptors include mammals, birds, amphibians, fish, and aquatic invertebrates for which quantitative risk estimates can be made, based on the program description data in this chapter and the environmental fate and transport predictions described in Chapter 3. Based on the results of this analysis, a qualitative assessment was conducted of risks to special status species—such as endangered, threatened, or other designated special status species, collectively referred to as “sensitive species” in this risk assessment—for whom the acceptable exposure threshold would be lower, to identify whether there could be risks to individual animals, as contrasted with protecting animal populations overall for non-sensitive species.

2.1.4 Ecosystems Potentially Affected

Retardants could be applied wherever a wildfire occurs, and no one ecosystem can represent the variety of site conditions that are found in all areas where wildland fire is possible. Therefore, this risk assessment identified representative ecoregions to be analyzed (see Table 2-1), based on the classifications described by Bailey (1995) and considering areas of the U.S. where fire-fighting chemicals are more likely to be applied.

The occurrence of peak fire season within an ecoregion is an important consideration in assessing risk to wildlife species, since that is when chemical use is more likely to happen. If chemical application coincides with the presence of vulnerable life stages of a species, adverse impacts may be more likely. The peak fire season for each ecoregion is noted in Table 2-1.

Table 2-1. Representative Ecoregions

Description	Ecoregion [a]	Geographic Location	Retardant Coverage Level (gpc, or gallons per 100 square feet) [b]	Peak Fire Season [c]
Annual and perennial western grasses	331: Great Plains-Palouse dry steppe	Rocky Mountain Piedmont, upper Missouri Basin Broken Lands, Palouse grassland of Washington and Idaho	1	Apr - Oct
Conifer with grass	M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow	Arizona, New Mexico	2	May - Jul
	M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow	Middle and southern Rocky Mountains	2	Jun - Sep
Shortneedle closed conifer	M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow	Blue Mountains, Salmon River Mountains, basins and ranges of southwestern Montana	2	Jun - Sep
	242: Pacific lowland mixed forest	Puget-Willamette lowland	2	Jul - Oct
Summer hardwood	234: Lower Mississippi riverine forest	Lower Mississippi River floodplain	2	Aug - May
Longneedle conifer	M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow	Adirondack-New England highlands	2	Mar - Jun Oct - Nov
Fall hardwood	231: Southeastern mixed forest	Southeastern U.S.	2	Oct - Jun
Sagebrush with grass	342: Intermountain semi-desert	Columbia-Snake River plateaus, Wyoming basin	3	Jun - Oct
Intermediate brush (green)	315: Southwest plateau and plains dry steppe and shrub	Texas, eastern New Mexico	3	Oct - Jul
Shortneedle conifer (heavy dead litter)	212: Laurentian mixed forest	North-central lake-swamp-morainic plains, New England lowlands	4	May, Aug, Nov
	M242: Cascade mixed forest–coniferous forest–alpine meadow	Pacific northwest	4	Jul - Oct
Southern rough	232: Outer coastal plain mixed forest	Atlantic and gulf coastal plains, Florida	6	Sep - Jul
Alaska black spruce	131: Yukon intermontane plateaus taiga	Interior Alaska	6	Jun - Sep
California mixed chaparral	M262: California coastal range open woodland–shrub–coniferous forest–meadow	Southern California coastal range	>6	Aug - Oct

[a] Numbers and categories correspond to those described by Bailey (1995).
[b] Mixed (diluted) product.
[c] Source: NFPA 2011.

2.2 Assessment Endpoints

Assessment endpoints are selected based on three criteria: ecological relevance, susceptibility to stressors, and relevance to management goals (EPA 1998). For species that are endangered, threatened, or sensitive, the assessment endpoint selected is individual survival, growth, and reproduction. For non-sensitive species present in an area that was treated with fire-fighting chemicals, the assessment endpoint selected is the survival of populations.

Scenarios describing the potential impacts of fire-fighting chemical use on the assessment endpoints are developed in the conceptual model described in the next section. Table 2-2 summarizes the potential ecological effects and associated assessment endpoints for this risk assessment of fire-fighting chemicals.

Table 2-2. Assessment Endpoints

Ecological Effect	Assessment Endpoint
Direct toxicity to terrestrial wildlife and aquatic species	For species that are endangered, threatened, or sensitive, the assessment endpoint selected is survival, growth, and reproduction of each individual. For non-sensitive species, the assessment endpoint selected is the survival of a majority of individuals to sustain a local population.
Direct ammonia toxicity to aquatic species	Acute and longer term lethal and sublethal toxicity to aquatic species from water-borne ammonia concentrations.
Phytotoxicity	Individual plant growth for endangered, threatened, or sensitive species; survival of populations for non-sensitive species.
Effects on vegetation diversity	Changes in vegetation species/succession in an area

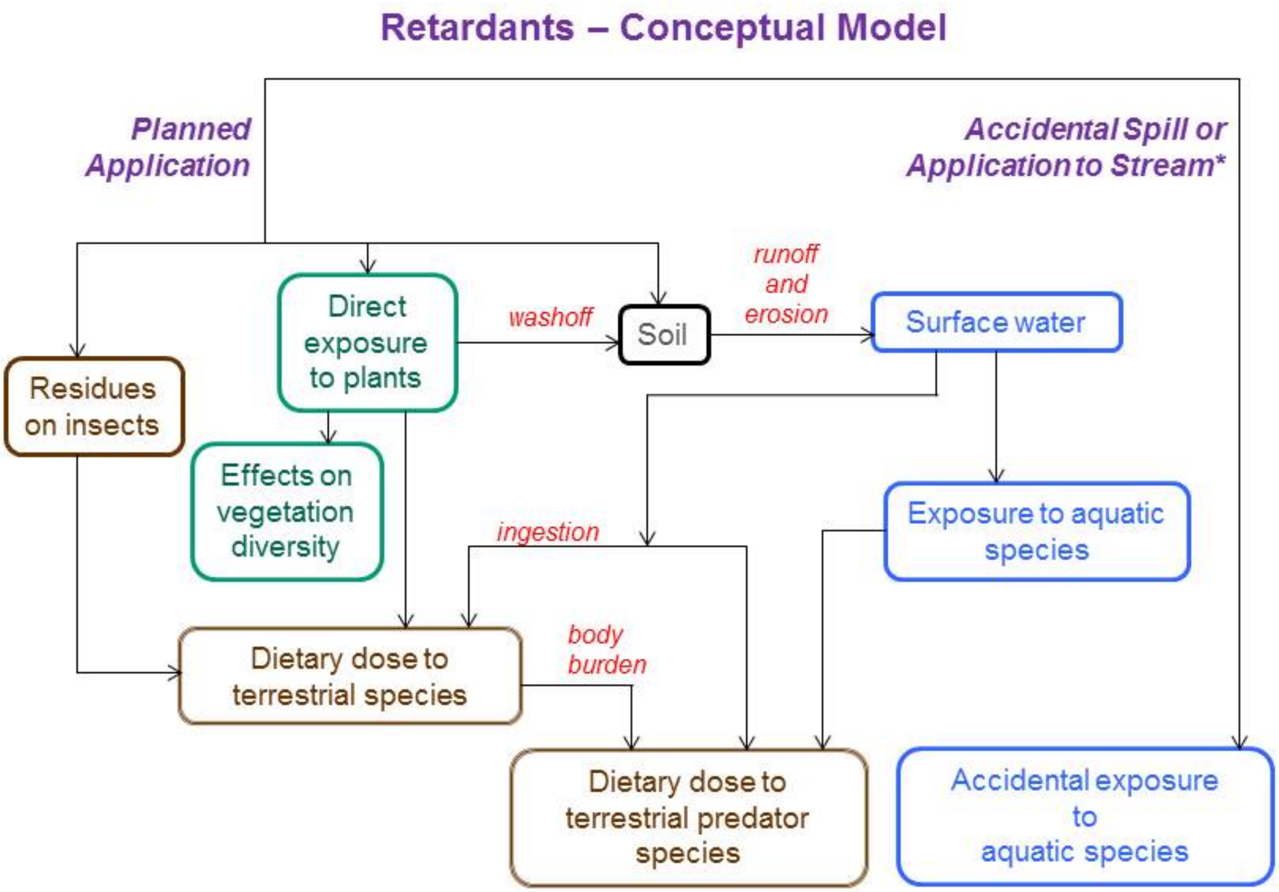
2.3 Conceptual Model

A conceptual model consists of (1) a risk hypothesis that describes relationships between the stressor, exposure, and assessment endpoint response; and (2) a diagram illustrating these relationships. For use of retardants on wildlands in the U.S., the risk hypothesis is as follows:

Risk Hypothesis
Some ingredients in the retardant products have demonstrated toxicity to terrestrial and aquatic wildlife and plant species, at varying levels, based on laboratory and field tests. The associated hypothesis is that use of retardants for wildland fire-fighting will cause chemical toxicity resulting from individual ingredients, or from the products as a mixture of ingredients. Environmental exposure to the chemical(s) is postulated to result in adverse effects to an individual's survival, growth, and reproduction for sensitive species, or to the survival of populations of non-sensitive species. Specifically, it is hypothesized that direct contact or soil-, water-, or diet-mediated exposure may occur at levels predicted to be associated with adverse individual or population-level effects.

To test this hypothesis, a conceptual model was developed to illustrate the relationships between stressors, exposure routes, and receptors. The conceptual model is presented in Figure 2-1.

Figure 2-1. Conceptual Model



*The "application to stream" scenario includes accidents as well as invoking an exception to the "Policy for Aerial Delivery of Wildland Fire Chemicals near Waterways" (USFS/DOI 2020).

2.4 Analysis Plan

Based on the conceptual model, scenarios were identified to evaluate risks to terrestrial and aquatic wildlife species from the identified assessment endpoints.

2.4.1 Direct Toxicity

Direct toxicity to wildlife species was characterized using the following steps:

1. Representative terrestrial and aquatic species and their characteristics were identified.

2. Each retardant formulation was screened for ingredients with high toxicity to wildlife, as determined by a mammalian oral median lethal dose (LD_{50}) <500 milligrams of chemical per

kilogram of body weight (mg/kg), or an acute aquatic species median lethal concentration (LC_{50}) <10 milligrams of chemical per liter of water (mg/L). These screening thresholds were based on inclusion of chemicals defined by EPA, in terms of their acute toxicity, as moderately, highly, or very highly toxic (EPA 2012a). EPA's toxicity categories are listed in Table 2-3.

Table 2-3. EPA Toxicity Categories

Receptor	Parameter and Units	Toxicity Category: Very highly toxic	Highly toxic	Moderately toxic	Slightly toxic	Practically nontoxic
Birds and wild mammals	acute oral LD_{50} (mg/kg)	<10	10 - 50	51 - 500	501 – 2,000	>2,000
Aquatic organisms	acute LC_{50} (mg/L)	< 0.1	0.1 - 1	>1 - 10	>10 - 100	>100

3. Effects characterization: for chemicals with high toxicity (as determined in the screening step above), profiles were prepared summarizing toxicity, chemical and physical and properties, and environmental fate and transport.

4. Exposure characterization: environmental fate and exposure models were implemented, to estimate exposures in terms of dose (mg/kg) for terrestrial species or concentration (mg/L) for aquatic species.

5. The doses and concentrations identified in the exposure characterization were compared to the toxic properties identified in the effects characterization, using the guidelines developed by EPA for interpreting risk estimates to wildlife and aquatic species.

2.4.2 Phytotoxicity

Impacts on terrestrial plants from ingredients in the retardant formulations were evaluated. The exposure characterization for plants was based on the same application scenarios as the exposure characterization for wildlife species. Limited data were expected to be available for the effects characterization, so the risk characterization was planned to be quantitative where possible and qualitative where data were limited.

2.4.3 Vegetation Diversity

Positive and negative effects of chemicals on plant species' growth were considered qualitatively. A major focus of the analysis was the potential for enhancement of invasive species' spread and corresponding decline of native species.

3.0 ANALYSIS

Exposures from both planned and accidental releases are considered in this risk assessment. Releases may include on-target drops to terrestrial areas, drops across water bodies, and accidental spills during aerial or ground transport to a stream. A drop across a stream may be accidental, or it may be an intended release as a result of invoking an exception under the "Interagency Policy for Aerial and Ground Delivery of Wildland Fire Chemicals Near Waterways and Other Avoidance Areas," a policy intended to protect aquatic species and certain terrestrial species.[3] This risk assessment evaluates each of these situations.

3.1 Data and Models for Analysis

A combination of laboratory study data, field study data, and modeling outputs was used in the ecological risk assessment.

Quantitative dose-response information for a range of animal species has been generated for chemicals in laboratory studies conducted by researchers and manufacturers. Sources include peer-reviewed scientific literature, manufacturers' material safety data sheets and information summaries, and government reports. These studies were reviewed to generate the LD_{50}s and LC_{50}s that are used in the ecological risk assessment.

Predicting the estimated environmental concentrations of the retardants in this analysis relied primarily on mathematical modeling for the following reasons:

- Little to no validated data are available from monitoring studies of retardant application, and the nationwide utility of data developed on environmental fate at individual sites would be limited, due to the significant influence of site-specific parameters (such as soil type, climate, slope, and other variables) on the potential for off-site transport; and
- Sophisticated models have been validated in field tests, and are appropriate for application to this problem, which seeks to identify a representative range of exposure estimates for each ecoregion.

The EPA and other regulatory agencies recognize the value of modeling for predicting impacts.

[3] The aerial delivery policy is to:

- Avoid aerial application of all wildland fire chemicals within 300 feet (ft.) of waterways.
- Additional mapped avoidance areas may be designated by individual agency.
- For FS, whenever practical, as determined by the fire incident commander, use water or other less toxic wildland fire chemical suppressants for direct attack or less toxic approved fire retardants in areas occupied by threatened, endangered, proposed, candidate or sensitive species or their designated critical habitats.

The ground delivery policy is to avoid application of all wildland fire chemicals into waterways or mapped avoidance areas.

For the Forest Service, exceptions can be made for the protection of life and safety (public or firefighter). Other agencies are allowed additional exceptions if alternative line construction tactics are not available, life or property is threatened, or potential damage to natural resources outweighs possible loss of aquatic life. The guideline is a joint policy of the U.S. Forest Service and the Department of the Interior.

Predicting environmental concentrations after the use of retardants is complicated by the wide range of chemical, environmental, and operational variables. To simplify the task, the modeler chooses a limited number of scenarios based on anticipated operations and circumstances. While the scenarios chosen in this study are intended for use in predicting expected conditions, a conservative bias was incorporated when assumptions were required. This is useful in overcoming the limitations and uncertainties that accompany modeling. If a model predicts that the less favorable circumstances produce acceptable results, then one can predict with greater confidence that the normal or more favorable circumstances will also produce acceptable results.

The computer-based Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model, described in detail in the following subsection, was used to estimate runoff of retardants from treated areas into streams, possibly exposing aquatic species as well as terrestrial species (through drinking water). Point source loading was assumed for edge-of-field runoff into streams and for accidental spills into streams. Residue levels on foliage and other wildlife diet items were estimated using the results of field studies (see Section 3.2.1).

3.1.1 Modeling of Runoff Using GLEAMS

The GLEAMS model, developed by the U.S. Department of Agriculture (USDA) Agricultural Research Service (Leonard et al. 1987, 1988), is a computerized mathematical model to evaluate the movement and degradation of chemicals in soil within the plant root zone under various crop management systems. Version 3.0 of GLEAMS, used for this analysis, includes improved handling of forested areas (Knisel and Davis 2000). The model has been tested and validated using a variety of data (see, for example, Leonard et al. 1987, Crawford et al. 1990). The following paragraphs briefly discuss the structure and function of the model.

3.1.1.1 Components

GLEAMS has four main components: hydrology, erosion, nutrients, and pesticides. The hydrology component of GLEAMS subdivides the soil within the rooting zone into as many as 12 computational layers. Soils data describing porosity, water retention characteristics, and organic matter content for the site-specific soil layers (horizons) are collected for model initialization. During a simulation, GLEAMS computes a continuous accounting of the water balance for each layer, including percolation, evaporation, and transpiration. Evaporation of chemicals from the soil surface is not represented, but evaporation of water can cause chemicals to move upward through the soil.

The erosion component of GLEAMS accounts for the basic soil particle size categories (sand, silt, and clay), and for small and large aggregates of soil particles. The program also accounts for the unequal distribution of organic matter between soil fractions, and uses this information and surface-area relationships to calculate an enrichment ratio that describes the greater concentration of chemicals in eroding soil compared with the concentration in surface soil.

The nutrient component of GLEAMS was used to model the retardant salts, which are the same chemicals that are used in the synthetic fertilizers that this component of the model was designed to evaluate. The model simulates the fate of nitrogen and phosphorus, applied as fertilizers, animal wastes, or tillage. Over long periods of time without nutrient supplementation, the nitrogen and phosphorus concentrations will stabilize and remain relatively constant, as is the case in modeling forest scenarios.

The pesticide component of GLEAMS can represent chemical deposition directly on the soil, the interception of chemicals by foliage, and subsequent washoff. Although retardants are not pesticides, GLEAMS appropriately represents the ingredients that are not retardant salts, since they are deliberately applied at known rates to defined areas. Degradation rates are allowed to differ between plant surfaces and soil, and between soil horizons. Degradation calculations are performed on a daily time interval. Redistribution of chemicals because of hydrologic processes is also calculated on a daily time step. Chemical distribution between dissolved and sorbed states is described as a simple linear relationship, directly proportional to the organic carbon partition coefficient[4] and soil organic matter content. Extraction of chemicals from the soil surface into runoff accounts for sorption (assumed to be relatively rapid) and uses a related parameter describing the depth of the interaction of surface runoff and surface soil. Chemical percolation is calculated through each of the soil layers, and the amount that passes through the last soil layer is accumulated as the potential loading to the vadose zone[5] or groundwater. Input data required by the GLEAMS model consist of several separate files representing rainfall data, temperature data, hydrology parameters, erosion parameters, nutrient parameters, and chemical parameters.

3.1.1.2 Parameter Files

The rainfall data file contains the daily rainfall for the period of simulation. The temperature data file contains the daily or monthly mean temperature for the simulation period. The model determines rain and snow from the temperature data file.

Daily precipitation amounts and temperatures were input into the GLEAMS model. These values were simulated by a weather generator model, CLIGEN (USDA 2003). CLIGEN was initially developed by the USDA Agricultural Research Service, and has since undergone significant changes, including recoding to conform to the Water Erosion Prediction Project Fortran-77 Coding Convention. CLIGEN is a stochastic weather generator that produces daily time series estimates of precipitation, temperature, dewpoint, wind, and solar radiation for a single geographic point, based on average monthly measurements for the period of climatic record. The estimates for each parameter are generated independently of the others. CLIGEN version 5.104 was used in this effort. In addition to daily precipitation amounts and temperatures, wind velocity, dew point, and solar radiation were also obtained from the CLIGEN model.

The hydrology parameter file contains information on the size, shape, and topography of the area to which chemicals were applied, hydraulic conductivity, soil water storage, and leaf area indices. This file also contains the runoff curve number, which describes the tendency for water

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[4] The organic carbon partition coefficient indicates the extent to which a chemical partitions itself between the solid and solution phases of a water-saturated or unsaturated soil, or runoff water and sediment. It is the ratio of the amount of chemical adsorbed to soil per unit weight of organic carbon in the soil or sediment, to the concentration of the chemical in solution at equilibrium. Typical units are (micrograms adsorbed per gram organic carbon) per (microgram per milliliter solution). Values could range from 1 to 10 million.

[5] The partially saturated region between the ground surface and the water table.

to run off the surface of the soil. Representative values for these parameters were identified from published soil surveys for each ecoregion.

The erosion parameter file contains information needed to calculate erosion, sediment yield, and sediment particle composition on a storm-by-storm basis. The input data can represent a number of optional configurations of fields, channels, and impoundments, but the scenarios for this analysis represented a single field for application of retardants in each ecoregion.

Parameter files were prepared for all ingredients, describing their water solubility, organic carbon partition coefficients, the tendency for the chemical to wash off plant surfaces, and the expected application rate and schedule. For modeling purposes, it was assumed that there were no residues of the chemical on the site at the beginning of the simulation, and that no degradation occurred during the evaluation period.

Nutrient parameter files were prepared containing information on typical mineral content from county soil surveys for each ecoregion, average nitrogen concentrations in rainfall for a geographic area, and application information for retardant salts.

3.1.1.3 Model Setup

The objective of this simulation was to estimate chemical sorption to soil and loss in runoff following application of retardants. Since an earlier risk assessment (USFS 1995) identified no likelihood that retardants and foams would leach below the rooting zone, the groundwater pathway was not evaluated in this assessment. The environmental input parameters were selected to represent the conditions in each ecoregion as realistically as possible.

Table 3-1 lists the specific soil characteristics used in the model simulations. These parameters are described to the modeled rooting depth of 24 to 60 inches (based on regional soil data), which can be interpreted as the depth from which water is actively taken up by the vegetation.

For each ecoregion, application of retardants was modeled using the application rates referenced in Table 2-1. Additional assumptions and inputs to the simulations included the following:

- Daily rainfall data were generated for a three-year period using CLIGEN. Simulations were run for a three-year period following application of the retardant to allow for variability of runoff concentrations from year to year and to be able to make statistical estimates of the frequency of occurrence of a given level of runoff. No environmental degradation of the chemicals was assumed, to insert a conservative bias into the modeling results. In addition, to provide an additional measure of conservatism, a five-year, 24-hour storm event was inserted on the day following the chemical application, providing an upper bound estimate for potential concentrations in surface water runoff.
- Temperature data were input as monthly average minimum and maximum, as simulated by CLIGEN.
- The vegetative cover factor (C) for erosion calculations was estimated to be 0.004, representing good cover primarily with grasses.

Table 3-1. Soil Characteristics within the Rooting Zone

Ecoregion	Soil Type	Runoff Curve Number	Hydraulic Slope (feet/feet)	Rooting Depth (inches)	Saturated Conductivity (inches/hour)*	Saturated Conductivity Below Root Zone (inches/hour)	Organic Matter (%)*	Erodibility Factor
Great Plains-Palouse dry steppe	sandy clay loam	60	0.050	60	0.15 / 0.15 / 0.15	0.15	2.26 / 1.57 / 1.20	0.200
Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow	clay loam	60	0.150	60	0.50 / 0.15 / 0.15	0.15	1.68 / 1.35 / 1.14	0.350
Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow	sandy loam	60	0.120	60	1.5 / 1.5 / 1.5	0.15	3.49 / 2.17 / 1.27	0.200
Middle Rocky Mountain steppe–coniferous forest–alpine meadow	loam	60	0.150	60	0.75 / 0.50 / 0.35	0.15	6.49 / 4.39 / 1.15	0.350
Pacific lowland mixed forest	silty loam	60	0.200	60	1.3 / 1.3 / 1.3	0.15	10.0 / 4.2 / 0.8	0.258
Lower Mississippi riverine forest	silt	60	0.150	60	0.2 / 0.2 / 0.2	0.15	4.15 / 0.84 / 0.32	0.350

Table 3-1. Soil Characteristics within the Rooting Zone (continued)

Ecoregion	Soil Type	Runoff Curve Number	Hydraulic Slope (feet/feet)	Rooting Depth (inches)	Saturated Conductivity (inches/hour)*	Saturated Conductivity Below Root Zone (inches/hour)	Organic Matter (%)*	Erodibility Factor
Adirondack-New England mixed forest–coniferous forest–alpine meadow	sandy loam	60	0.150	60	0.50 / 0.40 / 0.25	0.15	6.10 / 0.95 / 0.18	0.350
Southeastern mixed forest	sandy clay loam	60	0.150	60	4.0 / 0.8 / 2.0	0.15	1.0 / 1.0 / 1.0	0.326
Intermountain semi-desert	fine sandy loam	48	0.100	60	6.0 / 6.0 / 6.0	0.40	1.02 / 0.25 / 0.25	0.236
Southwest plateau and plains dry steppe and shrub	silty clay	60	0.100	60	0.5 / 0.3 / 0.3	0.15	2.91 / 2.12 / 1.80	0.250
Laurentian mixed forest	sandy loam	60	0.200	60	6.0 / 6.0 / 6.0	0.40	6.0 / 4.1 / 4.1	0.191
Cascade mixed forest–coniferous forest–alpine meadow	clay loam	60	0.120	60	1.3 / 1.2 / 0.4	0.15	3.68 / 3.46 / 1.40	0.296
Outer coastal plain mixed forest	loamy fine sand	60	0.030	60	6.0 / 6.0 / 6.0	0.30	4.7 / 4.7 / 4.7	0.100
Yukon intermontane plateaus taiga	silty loam	73	0.050	24	6.00 / 1.28 / 0.01	0.01	10.0 / 3.7 / 3.0	0.355
California coastal range open woodland–shrub–coniferous forest–meadow	sandy loam	60	0.250	36	1.84 / 0.88 / 0.03	0.03	5.06 / 3.43 / 1.96	0.182

A complete set of GLEAMS input and output tables was created for each combination of chemical and ecoregion.

GLEAMS output provides edge-of-field chemical concentrations in runoff. To estimate surface water concentrations that may result from runoff events, calculations were applied assuming the application occurred in two different areas: a small (6,400-acre) drainage basin with a 12-cubic-feet-per-second stream flowing through it, and a larger (147,200-acre) drainage basin with a 350-cubic-feet-per-second stream flowing through it. The stream sizes were selected to span the range likely to be present in areas where fire-fighting chemicals are applied. The sizes of the respective drainage basins were estimated by reviewing the sizes of drainage basins typically associated with these stream sizes in watersheds across the U.S. (USGS 2012).

3.1.1.4 Accuracy and Limitations of GLEAMS Modeling Predictions

For a detailed discussion of the validation of GLEAMS, its sensitivity to errors in input parameters, and its expected accuracy, the reader should refer to the model documentation referenced at the beginning of this section. The GLEAMS computer model can provide a large amount of information without having to conduct expensive field studies and the subsequent chemical analysis. However, the model is sensitive to input parameters. Since the ecoregion conditions modeled were intended to be representative of conditions within a large and variable geographic area, the model results will not specifically predict environmental transport at any precise location, but provide an indication of the general chemical behavior that may be expected under typical conditions. The variation of the parameters used from those that exist at a specific location causes the majority of uncertainty in the model's output.

In the fate modeling, environmental degradation of the chemicals—in soil or in surface water—was not credited for reducing concentrations of any chemicals over time, since the length of time elapsing between application and exposure could vary greatly, and could possibly be very short. A study conducted by the U.S. Geological Survey (Little and Calfee 2002) indicated that the substrate on which the fire retardant is applied could have a significant effect on its persistence in the terrestrial environment and subsequent potential to contaminate adjacent aquatic systems at levels that could be toxic to fish. In containers, retardant (applied at a rate equivalent to 1 gpc) was weathered outdoors for 7 to 45 days on soils with a high (3.7%) or low (1.4%) organic matter content or on sand (0.2% organic matter), a volume of water was added to each test system, and then fathead minnows were placed in the water for 24 hours. Lethality to test fish increased as organic matter content decreased, with non-first order relationships observed between elapsed time and toxicity, indicating multiple factors affecting chemical speciation, availability, and resultant toxicity. These factors could include (1) degradation at different rates to both less and more toxic chemical species by various components of the retardant formulation; (2) chemical composition of soil influencing binding/mobility of various ingredients; and (3) possible additive or synergistic toxicity among the mixture of ingredients and degradation products that exists at a given time during the weathering process. Overall, the relationship between elapsed time and toxicity of retardant residues in runoff has not been quantitatively determined, therefore precluding modeling estimates of degradation effects in this predictive risk assessment. However, it can be concluded that the time-toxicity relationship is complex and will vary according to site-specific conditions.

In general, any modeling estimates of chemical fate developed without a degradation factor will result in a conservative estimate.

3.1.2 Accidents

Average stream concentrations of chemicals were estimated one hour after a point-source accidental spill of a retardant during transport to fire-fighting operations, to both large and small streams. The volume spilled was assumed as follows:

- three 2,000-pound bulk bags of powdered retardant concentrate
- a 2,000-gallon tank of wet retardant concentrate
- a 2,000-gallon tank of mixed, diluted retardant

Retardant application directly across a stream was also evaluated for both small and large streams at the application rates used in each ecoregion.

3.2 Characterization of Exposure

3.2.1 Direct Toxicity

3.2.1.1 Terrestrial Species

The terrestrial species exposure scenarios postulate that a variety of terrestrial wildlife species may encounter residues of retardants when they re-enter areas after fire-fighting activities have subsided. The scenarios further postulate that these terrestrial species may be exposed to any applied chemicals through ingestion of contaminated food and water.

The list of representative terrestrial species is as follows:

<u>Mammals</u>
Deer (*Odocoileus* spp.) (large herbivore)
Coyote (*Canis latrans*) (carnivore)
Deer mouse (*Peromyscus maniculatus*) (omnivore, prey species)
Rabbit (*Sylvilagus* spp.) (small herbivore)
Cow (*Bos taurus*) (ruminant)

<u>Birds</u>
American kestrel (*Falco sparverius*) (raptor)
Red-winged blackbird (*Agelaius phoeniceus*) (songbird)
Bobwhite quail (*Colinus virginianus*) (ground nester)

These particular wildlife species were selected because they represent a range of taxonomic classes, body sizes, foraging habitat, and diets for which parameters are generally available. For each species, characteristics were identified that were used in estimating doses of ingredients in the retardants. These characteristics include body weight, dietary intake, composition of diet, and home range/foraging area. There were insufficient data available on the toxicity of the retardant products and their ingredients to reptiles and terrestrial stages of amphibians to include representatives of these classes in the analysis.

In a screening-level risk assessment such as this one, emphasis on the dietary route of exposure is appropriate (EPA 2004), For terrestrial wildlife, exposures were assumed to occur through ingestion of forbs, berries, insects, or seeds in a treated area, and, if relevant, ingestion of prey with residues or body burden. In addition, terrestrial species' drinking water was assumed to come from a small stream receiving runoff, as estimated in the analysis described in Section 3.1.1, using the highest small stream concentration predicted for each application rate.

Residues on food items were estimated using the results of field studies by Hoerger and Kenaga (1972), as updated by Fletcher et al. (1994, as cited in Pfleeger et al. 1996). Table 3-2 lists the residue levels predicted.

Table 3-2. Residue Levels

Item	Residue (ppm per pound/acre) [a]
Grass	175 [b]
Leaves	135
Forage	135
Small insects	135 [c]
Fruits	15
Pod containing seeds	12
Large insects	12 [b]

[a] ppm = parts per million
[b] Mean of short range grass and long grass.
[c] EPA's Office of Pesticide Programs groups small insects with broadleaf/forage plants and large insects with fruits, pods, and seeds (EPA 1999).

Predators that feed on other animals were assumed to receive the total body burden that each of the prey species received. Wildlife that feed on aquatic species were assumed to receive residue levels based on the chemical concentrations in water in a small stream and chemical-specific bioconcentration factors (the concentration of a chemical in aquatic organisms divided by the concentration in the surrounding water). In both cases, the appropriate prey body burden (appropriate to the prey's exposure as either another terrestrial species or an aquatic species) was incorporated into the "*RES*" term in the equation described in the next paragraph.

The doses for terrestrial wildlife from the food items comprising each species' diet were summed, as follows:

$$DOSE = \left[FRAC \times DIET \times CON \times TA \times RATE \times \left(\sum_{i=1}^{n} RES_i \times INT_i \right) \right] \div BW$$

where:

DOSE	=	dose to wildlife species (mg/kg)
FRAC	=	fraction of diet assumed to be contaminated, a function of foraging range affected (0.05 to 0.25, depending on size of range) and the fraction of consumed food consisting of contaminated items (0.25, based on professional judgment per heterogeneous coverage within treated area and possible avoidance behavior)
DIET	=	mass of total daily dietary intake (kg)
TA	=	fraction of treated area in an acre (0.32, based on average swath width of 67.5 feet)
RATE	=	application rate of ingredient (pound/acre)
RES_i	=	chemical residues on food item *i* (milligrams residues per kilogram food item, as related to application rate in pound/acre)
INT_i	=	fraction of daily diet consisting of food item *i*
BW	=	body weight (kg)

To predict the total ingestion dose to terrestrial species, these food item doses were added to the estimated doses from the animal drinking all of its water from a small stream that received runoff. The species-specific parameters used in this analysis are summarized in Table 3-3.

3.2.1.2 Aquatic Species

The aquatic species exposure scenarios postulate that fish, tadpoles, and aquatic invertebrates in small and large streams may be exposed to ingredients in retardant products through contaminated runoff coming off of areas to which the chemicals had been applied, or as a result of an accidental spill or drop into a stream.

For each chemical, risks were estimated for aquatic species for which ecotoxicity data are available. Representative aquatic species are as follows:

<u>Aquatic Species</u>
Rainbow trout (*Oncorhynchus mykiss*) (coldwater fish)
Water flea (*Daphnia* spp.) (aquatic invertebrate)
Tadpoles of frog or toad species, depending on data available (aquatic stages of amphibians)

In addition, a brief evaluation of risks from ammonia in the retardant products to freshwater mussels was conducted. A lack of toxicity data precluded quantification of risks to other benthic organisms.

The concentrations of the chemicals in streams were estimated using the environmental fate and transport modeling methodologies described in Section 3.1.

Table 3-3. Exposure Assessment Parameters for Terrestrial Species

Parameter	Species							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
Body weight (kg)	66.5	13	0.021	2.5	1102	0.11	0.052	0.18
Total diet (kg/day)	1.45635	0.68	0.00399	0.1	10	0.3	0.00849261	0.0144
Fraction of diet								
Grass	0.05	0	0.026	0.7	0	0.05	0.26	0.05
Leaves/forage/ small insects	0.95	0.03	0.379	0.3	0.035	0.7	0.249	0.95
Fruits	0	0	0.154	0	0	0	0.113	0
Pods/seeds/ legumes/large insects	0	0.01	0.446	0	0.326	0.25	0.378	0
Mammals	0	0.785	0	0	0.317	0	0	0
Birds	0	0.175	0	0	0.322	0	0	0
Foraging range (acres)	196	7437.71	0.17297	44.478	5	370.65	1	8.8956
Foraging range affected	0.1	0.05	0.25	0.1	0.1	0.05	0.1	0.1
Drinking water (L/kg-day)	0.104	0.0766	0.19	0	0.0491	0.15	0.157	0.115

3.2.2 Phytotoxicity

The potential toxicity to plants of ingredients in the retardants was evaluated semi-quantitatively, depending on the nature of the chemical-specific plant toxicity information that was available for each ingredient, if any.

3.2.3 Vegetation Diversity

This topic was evaluated qualitatively based on a literature review of the effects of fire suppression on the vegetative community. Available literature was limited and was both habitat- and chemical-specific.

3.3 Characterization of Ecological Effects: Ecological Response Analysis and Development of Stressor-Response Profiles

3.3.1 Toxicity of Individual Ingredients

The ingredients in the retardant products were individually reviewed to identify their direct toxicity to terrestrial and aquatic wildlife species. The following screening process was applied to focus the analysis on chemicals with greater potential for effects to wildlife (see Section 2.4.1):

- Ingredients were evaluated if the acute oral LD_{50} for terrestrial species was less than 500 mg/kg.
- Ingredients were evaluated if the acute LC_{50} for aquatic species was less than 10 mg/L.
- All of the retardant salts were retained in the analysis.

In all cases, the toxicity data indicating the greatest sensitivity to the chemical were used, regardless of life stage. Detailed profiles for each chemical are on file with the Forest Service's Wildland Fire Chemicals System program. A toxicity endpoint was sought for each of the representative species evaluated in this risk assessment; however, an LD_{50} for other species was used if no data were available for the species evaluated. For example, if no LD_{50} was found for Chemical X from a study using a coyote, an LD_{50} determined for another mammalian species, such as a rat, was used to derive the risk estimates for the coyote from Chemical X. If no data were available at all for a class (for example, no data for any bird species), a mammalian value was substituted, which increased uncertainty but allowed the analysis of risk to that species to proceed.

For the other endpoints in this ecological risk assessment (phytotoxicity and vegetation diversity), the stressor-response descriptions are incorporated into the respective risk characterization discussions in Section 4.0.

3.3.2 Laboratory and Field Studies Using Formulated Products

In addition to the laboratory study data for targeted ingredients, the results of laboratory and field studies using formulated products were reviewed. Acute oral and dermal toxicity studies using laboratory mammals, and acute lethality studies using rainbow trout, are conducted for each product on the QPL. For some products, studies are also available for additional mammalian and fish species, and various species of birds, earthworms, and aquatic invertebrates.

For each product, these data are discussed qualitatively in terms of the results of the quantitative risk assessment that used the individual ingredient data. However, because the formulated products are mixtures of several ingredients, each of which behaves differently in the environment, it is more appropriate for this risk assessment to evaluate the individual ingredients' risks to terrestrial and aquatic species,[6] since their exposure to the chemicals is mediated by each ingredient's properties during environmental transport or solution / suspension in surface water.

Field studies conducted by Vyas et al. (1997) were also reviewed. In the first of two experiments, the application of a retardant that is no longer commercially available (containing monoammonium phosphate and diammonium sulfate) had no effect on small mammal populations when applied at a rate of 1 gpc in a mixed-grass prairie ecosystem in North Dakota. In the second experiment, the same product was applied to a Great Basin sagebrush/riparian ecosystem in Nevada, again resulting in no detectible effect on small mammal abundance, survival, recruitment, and movement, or on biochemical indices from tissue and blood samples. The retardant application rate in the Nevada test was 3 gpc.

[6] The risk assessment includes the summation of risks from the ingredient mixtures (that is, products), assuming additivity in accordance with EPA guidance; see approach to assessing risks from mixtures in Section 4.1.1.

4.0 RISK CHARACTERIZATION

Risk characterization is the last step in the ecological risk assessment process. The exposure profile is compared to the stressor-response profile, to estimate the likelihood of adverse effects.

4.1 Direct Toxicity

4.1.1 Methodology for Estimating Risks

By comparing the exposure profile data (estimated dose or water concentration) to the stressor-response profile data (LD_{50}s, LC_{50}s), an estimate of the possibility of adverse effects can be made. The potential risks were characterized following the quotient methodology used by EPA's Office of Pesticide Programs (EPA 2012b). The quotient is the ratio of the exposure level to the hazard level. For acute exposures, the levels of concern at which a quotient is concluded to reflect risk to wildlife species are as follows (EPA 2012b):

- Non-sensitive terrestrial species: 0.5, where dose equals one-half the LD_{50}
- Sensitive terrestrial species (endangered, threatened, other special status): 0.1, where dose equals one-tenth the LD_{50}
- Non-sensitive aquatic species: 0.5, where water concentration equals one-half the LC_{50}
- Sensitive aquatic species (endangered, threatened, other special status): 0.05, where water concentration equals one-twentieth the LC_{50}

Because the retardant products are mixtures of ingredients, terrestrial or aquatic wildlife could be exposed to more than one of the individual ingredients at a time. In accordance with current EPA guidance on assessing the risks from chemical mixtures (EPA 1986), an additive approach (in the absence of any data indicating synergistic or antagonistic interactions) was used in these cases, in which the risk quotients of all "screened-in" (see Section 3.3.1) ingredients in a single product were summed, providing an additive risk quotient indicating the risk from the product as a whole. The additive quotient is interpreted in the same manner as a quotient for a single ingredient; that is, risk is presumed to exist if the additive quotient exceeds the thresholds listed in Section 4.1.1. For example, if two ingredients in Product A had terrestrial risk quotients of 0.005 and 0.001, the additive quotient from summing them would equal 0.006. This additive quotient would be evaluated using the criteria listed above for terrestrial species, determining that it does not exceed 0.5 or 0.1, indicating no additive risk from the ingredients in that product to either non-sensitive or sensitive terrestrial species, respectively.

For terrestrial species, in addition to this additive ingredient assessment, risks based on the formulated products' toxicity data were also estimated.

A similar risk estimate for the formulated product as a whole was not developed for aquatic species, because each individual chemical in a product has specific environmental transport characteristics. These properties determine its predicted runoff behavior and estimated stream concentrations, precluding any aggregated environmental fate modeling approach that would be required to estimate whole-product water concentrations from runoff.

Where risks are identified, they can be interpreted to mean that the identified exposure level (1) could be associated with loss of at least half of a local population of non-sensitive species, or (2) puts individual animals of sensitive species at risk of mortality. The levels of concern identified above are used by EPA as a policy tool to interpret the risk quotient and to analyze potential risk to terrestrial and aquatic organisms (EPA 2012b). For determining the presence of chronic risks, EPA lists the level of concern as the point at which the estimated environmental concentration is less than the “no-observed-effect concentration” (NOEC) from a laboratory or field study. Since NOECs were not consistently available for the retardants, and further, since most exposures are expected to be short-term, intermittent, or one-time events, a chronic analysis for all the ingredients in all the products was not conducted as part of this risk assessment. However, possible sublethal effects (including those from longer-term exposures) from the ingredients in approved products is an area of ongoing inquiry within the Forest Service. To date, these efforts have produced an evaluation of such effects to aquatic species from the ammonium compounds in the retardant products; this evaluation is discussed in Section 4.1.2.2.

4.1.2 Current Direct Toxicity Risk Summary (June 2020)

This section summarizes the ecological risk assessments for the retardants listed on the May 5, 2020, QPL at https://www.fs.fed.us/rm/fire/wfcs/index.htm. Any time that list is updated, the current applicability of this section of this report will change. This section will be updated as federal agency resources and priorities allow.

Appendices A and B present product-specific information and estimates of the retardant products' risks to terrestrial and aquatic wildlife species from routine uses and accident scenarios.

4.1.2.1 Estimated Risks to Terrestrial Species

Table 4-1 summarizes the estimated direct toxicity risks to terrestrial wildlife from the ingredients in the retardant products. (The same risk summary organized by product is presented in Table 4-2.) Risks were identified for sensitive species from a retardant salt at its concentration in four products. In addition, additive risks were estimated for sensitive species from ingredients screened into the analysis for seven products. Product risks, based on the formulated product LD_{50}, were identified to some sensitive species when applied at rates of 3 gpc or higher for eight products.

Table 4-1. Estimated Risks to Terrestrial Wildlife Species

Ingredient	Product	Applied Rate (gpc product) [a]	Representative Species	Risk? [b]	
				Sensitive Species	Non-Sensitive Species
Retardant salt #1	Phos-Chek LC95A-R Phos-Chek LC95A-Fx Phos-Chek LC95A-F Phos-Chek LC95W	2,3,4,6	Deer mouse	X	
		4,6	American kestrel	X	
		3,4,6	Red-winged blackbird	X	
Additive risk [c]	Phos-Chek MVP-Fx	4,6	Deer mouse	X	
	Phos-Chek 259-Fx Phos-Chek LCE20-Fx	6	Deer mouse	X	
	Phos-Chek LC95A-R Phos-Chek LC95A-Fx Phos-Chek LC95A-F Phos-Chek LC95W	2,3,4,6	Deer mouse	X	
		4,6	American kestrel	X	
		3,4,6	Red-winged blackbird	X	
Product risk [d]	Phos-Chek MVP-Fx Phos-Chek MVP-F Phos-Chek 259-Fx	6	Deer mouse	X	
	Phos-Chek LC95A-R Phos-Chek LC95A-Fx Phos-Chek LC95A-F Phos-Chek LC95W Phos-Chek LCE20-Fx	3,4,6	Deer mouse	X	
		6	American kestrel Red-winged blackbird	X	

[a] gpc = gallons per 100 square feet
[b] Risk quotients are listed in Appendices A and B.
[c] For some products, there may be no risk to this animal at this rate from any individual ingredients, but an additive risk from all ingredients.
[d] Based on formulated product's LD_{50}.

The following table summarizes the estimated risks overall for each product to the classes of wildlife evaluated, including risks identified based on the analysis of specific ingredients, the additive risk posed by all ingredients screened in to the analysis, and risks based on the toxicity of the formulation as a whole. As described in Section 3.2.1.1, the animals evaluated represent the following classes of wildlife:

- Deer: large herbivore
- Coyote: carnivore
- Deer mouse: omnivore, prey species
- Rabbit: small herbivore
- Cow: ruminant
- American kestrel: raptor
- Red-winged blackbird: songbird
- Bobwhite quail: ground nester

Table 4-2. Product Risk Summary for Terrestrial Species

Retardant	Risks to Sensitive Species / Rate [a]	Risks to Non-Sensitive Species / Rate [a]
Phos-Chek MVP-Fx	Omnivore / 4,6 gpc	—
Phos-Chek MVP-F	Omnivore / 6 gpc	—
Phos-Chek 259-Fx	Omnivore / 6 gpc	—
Phos-Chek LC-95A-R	Omnivore / 2,3,4,6 gpc Raptor / 4,6 gpc Songbird / 3,4,6 gpc	—
Phos-Chek LC-95A-Fx	Omnivore / 2,3,4,6 gpc Raptor / 4,6 gpc Songbird / 3,4,6 gpc	—
Phos-Chek LC-95A-F	Omnivore / 2,3,4,6 gpc Raptor / 4,6 gpc Songbird / 3,4,6 gpc	—
Phos-Chek LC-95-W	Omnivore / 2,3,4,6 gpc Raptor / 4,6 gpc Songbird / 3,4,6 gpc	—
Phos-Chek LCE20-Fx	Omnivore / 3,4,6 gpc Raptor / 6 gpc Songbird / 6 gpc	—

[a] gpc = gallons per 100 square feet.

4.1.2.2 Estimated Risks to Aquatic Species

Acute Toxicity from Intended Applications and Accidents

None of the retardant products were predicted to pose a risk of acute effects for aquatic wildlife from runoff to streams. The runoff exposure scenario is intended to predict risks to aquatic species from non-accidental use; that is, when all application guidelines are followed and no spills or applications across streams occur.

Table 4-3 summarizes the estimated risks of direct toxicity to aquatic wildlife from the retardant products in the case of a retardant application across a stream. Risks were identified for multiple products from three retardant salts, two pigment ingredients, and additive risks from individual ingredients.

The risks by ecoregions correlated exactly with the application rates modeled for the ecoregions, so the risks are presented in terms of application rate (1, 2, 3, 4, or 6 gpc) instead of in terms of the 15 ecoregions, to simplify the risk summary. The application rates, by representative ecoregion, are as follows (as previously listed in Table 2-1):

- 1 gpc: annual and perennial western grasses
- 2 gpc: conifer with grass, shortneedle closed conifer, summer hardwood, longneedle conifer, fall hardwood
- 3 gpc: sagebrush with grass, intermediate brush (green)
- 4 gpc: shortneedle conifer (heavy dead litter – north-central/New England), shortneedle conifer (heavy dead litter – Pacific northwest)
- 6 gpc: southern rough, Alaska black spruce, California mixed chaparral

Table 4-3. Estimated Risks to Aquatic Wildlife Species from Accidental Stream Application of Mixed (Diluted) Retardant

Ingredient	Product	Applied Rate (gpc) / stream size [a]	Representative Species	Risk? [b] Sensitive Species	Risk? [b] Non-Sensitive Species
Retardant salt #1	Phos-Chek MVP-Fx Phos-Chek MVP-F	6 small stream	Tadpole	X	
	Phos-Chek LCE20-Fx	4,6 small stream	*Daphnia magna*	X	
Retardant salt #2	Phos-Chek 259-Fx	3-6 small stream	Rainbow trout	X	
	Phos-Chek LCE20-Fx	6 small stream	Rainbow trout	X	
		2,3,4,6 small stream	*Daphnia magna*	X	
Retardant salt #3	Phos-Chek LC-95A-R Phos-Chek LC-95A-Fx Phos-Chek LC-95A-F Phos-Chek LC-95W	3,4,6 small stream	Rainbow trout	X	
Pigment ingredient #1	Phos-Check MVP-Fx Phos-Chek 259-Fx Phos-Chek LC-95A-Fx	6 small stream	Rainbow trout *Daphnia magna*	X	
Pigment ingredient #2	Phos-Chek LCE20-Fx	3,4,6 small stream	*Daphnia magna*	X	

Table 4-3. Estimated Risks to Aquatic Wildlife Species from Accidental Stream Application of Mixed (Diluted) Retardant (continued)

Ingredient	Product	Applied Rate (gpc) / stream size [a]	Representative Species	Risk? [b]	
				Sensitive Species	Non-Sensitive Species
Additive risk [c]	Phos-Chek 259-Fx Phos-Chek LC-95A-Fx Phos-Chek LCE20-Fx	2,3,4,6 small stream	Rainbow trout	X	
	Phos-Chek MVP-Fx Phos-Chek LC-95A-R Phos-Chek LC-95A-F Phos-Chek LC-95W	3,4,6 small stream	Rainbow trout	X	
	Phos-Chek MVP-F	6 small stream	Rainbow trout Tadpole	X	
	Phos-Chek MVP-Fx	6 small stream	Tadpole	X	
	Phos-Chek MVP-Fx Phos-Chek LC-95A-Fx	4,6 small stream	*Daphnia magna*	X	
	Phos-Chek 259-Fx	3,4,6 small stream	*Daphnia magna*	X	
	Phos-Chek LCE20-Fx	1,2,3,4,6 small stream 6 large stream	*Daphnia magna*	X	
Product risk [d]	None				

[a] gpc = gallons per 100 square feet; see Section 3.1.1.3 for discussion of stream sizes.
[b] Risk quotients are listed in Appendices A and B.
[c] For some products, there may be no risk to this animal at this rate from any individual ingredients, but an additive risk from all ingredients.
[d] Based on formulated product's LC_{50} (only estimated in this scenario for products assessed June 2020 and later).

Accidental spills were far more likely to lead to a prediction of risk in this analysis compared to applications across a stream. All retardant products present a significant risk to sensitive aquatic species when concentrate or mix is spilled into small or large streams at the volumes assumed in this risk assessment. In most cases, risks were predicted to non-sensitive species as well. The tables in Appendices A and B present the estimated risk quotients for these accident scenarios.

Table 4-4 summarizes the estimated risks overall for each product to the types of aquatic wildlife evaluated, including risks identified based on the analysis of specific ingredients, and the additive risk posed by all ingredients screened in to the analysis. As described in Section 3.2.1.2, the animals evaluated represent the following classes of aquatic wildlife:

- Rainbow trout: coldwater fish
- Water flea (*Daphnia magna*): aquatic invertebrates
- Frog or toad tadpole: aquatic stages of amphibians

Table 4-4. Product Risk Summary for Aquatic Species (based on ingredient toxicity)

Retardant	Scenario	Risks to Sensitive Species / Stream Size / Coverage Level (gpc)	Risks to Non-Sensitive Species / Coverage Level (gpc)
Phos-Chek MVP-Fx	Runoff	—	—
	Application to stream	Fish / small / 3-6 gpc Aquatic invertebrates / small / 4-6 gpc Amphibians / small / 6 gpc	—
	Bulk bag spill	Fish / small and large Aquatic invertebrates / small and large Amphibians / small and large	Fish / small and large Aquatic invertebrates / small and large Amphibians / small and large
	Mixed retardant spill	Fish / small and large Aquatic invertebrates / small and large Amphibians / small and large	Fish / small Aquatic invertebrates / small Amphibians / small
Phos-Chek MVP-F	Runoff	—	—
	Application to stream	Fish / small / 6 gpc Amphibians / small / 6 gpc	—
	Bulk bag spill	Fish / small and large Aquatic invertebrates / small and large Amphibians / small and large	Fish / small and large Aquatic invertebrates / small Amphibians / small and large
	Mixed retardant spill	Fish / small and large Aquatic invertebrates / small and large Amphibians / small and large	Fish / small Aquatic invertebrates / small Amphibians / small
Phos-Chek 259-Fx	Runoff	—	—
	Application to stream	Fish / small / 2-6 gpc Aquatic invertebrates / small / 3-6 gpc	—
	Bulk bag spill	Fish / small and large Aquatic invertebrates / small and large Amphibians / small and large	Fish / small and large Aquatic invertebrates / small and large Amphibians / small
	Mixed retardant spill	Fish / small and large Aquatic invertebrates / small and large Amphibians / small and large	Fish / small and large Aquatic invertebrates / small Amphibians / small
Phos-Chek LC-95A-R	Runoff	—	—
	Application to stream	Fish / small / 3-6 gpc	—
	Liquid concentrate spill	Fish / small and large Aquatic invertebrates / small and large	Fish / small and large Aquatic invertebrates / small
	Mixed retardant spill	Fish / small and large Aquatic invertebrates / small and large	Fish / small Aquatic invertebrates / small
Phos-Chek LC95A-Fx	Runoff	—	—
	Application to stream	Fish / small / 2-6 gpc Aquatic invertebrates / small / 4-6 gpc	—
	Liquid concentrate spill	Fish / small and large Aquatic invertebrates / small and large	Fish / small and large Aquatic invertebrates / small
	Mixed retardant spill	Fish / small and large Aquatic invertebrates / small and large	Fish / small and large Aquatic invertebrates / small

Table 4-4. Product Risk Summary for Aquatic Species (based on ingredient toxicity) (continued)

Retardant	Scenario	Risks to Sensitive Species / Stream Size / Coverage Level (gpc)	Risks to Non-Sensitive Species / Coverage Level (gpc)
Phos-Chek LC-95A-F	Runoff	—	—
	Application to stream	Fish / small / 3-6 gpc	—
	Liquid concentrate spill	Fish / small and large Aquatic invertebrates / small and large	Fish / small and large Aquatic invertebrates / small
	Mixed retardant spill	Fish / small and large Aquatic invertebrates / small and large	Fish / small Aquatic invertebrates / small
Phos-Chek LC-95W	Runoff	—	—
	Application to stream	Fish / small / 3-6 gpc	—
	Liquid concentrate spill	Fish / small and large Aquatic invertebrates / small and large	Fish / small and large Aquatic invertebrates / small
	Mixed retardant spill	Fish / small and large Aquatic invertebrates / small and large	Fish / small Aquatic invertebrates / small
Phos-Chek LCE20-Fx	Runoff	Aquatic invertebrates / small / 2,3,6 gpc	—
	Application to stream	Fish / small / 4-6 gpc Aquatic invertebrates / small / 1-6 gpc Aquatic invertebrates / large / 6 gpc	—
	Liquid concentrate spill	Fish / small and large Aquatic invertebrates / small and large	Fish / small and large Aquatic invertebrates / small and large
	Mixed retardant spill	Fish / small and large Aquatic invertebrates / small and large	Fish / small Aquatic invertebrates / small and large

No whole-product analysis was attempted for the aquatic species exposures scenarios from runoff, since each ingredient's environmental behavior (for example, adsorption to soil and solubility in runoff water) would be influenced, if not wholly determined, by that chemical's specific chemical and physical properties, and not by the product's characteristics. The updated methodology (June 2020 and later) includes whole-product aquatic species risk estimates for accident scenarios.

As previously noted, degradation was not taken into account in the modeling for this risk assessment, since no "expected" length of time can be identified between application and precipitation. Therefore, the selected approach errs on the conservative side to avoid underestimating potential exposures if the actual interim period was brief, which would allow only minimal (if any) degradation to occur. Little and Calfee (2002) studied the environmental persistence of fire retardants, and concluded that:

> ...soil composition appears to be a critical variable when evaluating the environmental hazards of these fire-retardant chemicals. Even though applications are quite high relative to LC50 concentrations for fish, the weathering of these materials on soils having 3 to 5 percent organic matter would rapidly diminish toxicity of short-term exposures.

Risks from Sublethal or Longer-Term Ammonia Exposure

In 2009, Labat Environmental reviewed the toxicity of ammonia to aquatic species, with an emphasis on data developed after EPA's 1999 updated ambient water quality criteria for ammonia were published (EPA 1999, LEI 2009). The EPA criteria, as well as the newer toxicity data that have been generated, are dependent on site-specific pH, since at higher pH, the balance of un-ionized ammonia (NH_3) to ionized ammonium (NH_4^+) shifts to favor the more toxic un-ionized NH_3. The following table summarizes the most sensitive endpoints identified in this literature review.

Table 4-5. Ammonia Toxicity Endpoints

Acute Lethal Effects	Short-Term Sublethal Effects	Long-Term Effects
Fish		
Atlantic salmon parr 96-hour LC_{50} at pH of 6.4 0.030 to 0.146 mg NH_3-N/L	fathead minnows significant decreases in the number of larvae at hatch and larval survival in exposed until hatch LOEC = 0.26 mg NH_3-N/L NOEC = 0.17 mg NH_3-N/L	juvenile Nile tilapia 75 days exposure decreased specific growth rate LOEC = 0.144 mg NH_3-N/L NOEC = 0.068 mg NH_3-N/L
Aquatic Invertebrates (exclusive of bivalves)		
rainbow mussel glochidia 24-hour LC_{50} 0.11 mg NH_3-N/L	amphipod *Gammarus duebeni celticus* precopula pair disruption (an indicator of stress with reproductive implications) LOEC = 0.12 mg NH_3/L	water flea 21 days exposure effects on survival and reproduction LOEC = 0.87 mg NH_3-N/L
Bivalves		
juvenile fatmucket 48-hour LC_{50} 0.09 mg N/L	Plain pocketbook growth effects 96-hour EC_{50} = 0.030 mg NH_3-N/L	fingernail clam 60 days effects on survival and reproduction LOEC = 0.046 mg NH_3-N/L NOEC = 0.011 mg/NH_3-N/L
Aquatic Stages of Amphibians		
African clawed toad 10-day LC_{50} 0.33 mg NH_3/L	African clawed toads effects on length and weight LOEC = 0.07 mg NH_3/L	green frog 114 days effects on survival and growth LOEC = 0.5 mg NH_3/L

LC_{50} = median acute lethal concentration
N = nitrogen
NH_3-N = nitrogen present as unionized ammonia
mg/L = milligrams per liter
LOEC = lowest-observed-effect concentration
NOEC = no-observed-effect concentration
EC_{50} = median effective concentration

Using terminology published by EPA, for its acute toxicity only, ammonia can be considered very highly toxic to fish and bivalves, and highly toxic to other aquatic invertebrates and aquatic stages of amphibians.

Fish exhibited the greatest susceptibility to acute lethal effects, while bivalves were the most sensitive to short-term sublethal effects and to the long-term effects of ammonia. Overall, the most sensitive endpoint identified was 0.030 mg NH_3-N/L.

In this risk assessment, the highest stream concentrations of retardant salts from the runoff scenario, in terms of mg [NH_3+NH_4^+]-N/L, are listed in Table 4-5. Conservatively assuming that the surface water pH was high enough to shift the balance so that this was entirely present in the form of NH_3-N, this concentration could be reviewed as follows in consideration of the ammonia toxicity endpoints listed in Table 4-5:

Table 4-6. Sublethal and Long-Term Ammonia Effects from Runoff

Retardant	Modeled max [NH_3+NH_4^+]-N concentration (mg/L)	Potential Risk [b]			
		Fish (NOEC = 0.17 sublethal, 0.068 long-term)	Aquatic Invertebrates [a] (0.1 LOEC = 0.012 sublethal, 0.087 long-term)	Bivalves (0.1 EC_{50} = 0.003 sublethal, NOEC = 0.011 long-term)	Aquatic Stages of Amphibians (0.1 LOEC = 0.007 sublethal, 0.05 long-term)
Phos-Chek MVP-Fx	0.00124	—	—	—	—
Phos-Chek MVP-F	0.00125	—	—	—	—
Phos-Chek 259-Fx	0.00334	—	—	potential risks of sublethal effects	—
Phos-Chek LC-95A-R	0.000184	—	—	—	—
Phos-Chek LC95A-Fx	0.000181	—	—	—	—
Phos-Chek LC-95A-F	0.000185	—	—	—	—
Phos-Chek LC-95W	0.000184	—	—	—	—
Phos-Chek LCE20-Fx	0.00326	—	—	potential risks of sublethal effects	—

[a] Exclusive of bivalves.
[b] Risks identified if modeled concentration exceeds NOEC, or 0.1 x LOEC or EC_{50} if no NOEC was identified.
Note: The risks are presented based on the data listed in Table 4-5.

Although risks of sublethal effects and risks from long-term exposures to ammonia are identified for one product in the analysis above, this conclusion is extremely conservative and represents an upper bound on the potential risks. Some amount, depending on the stream's pH, of the ammonium compound would be present as the ionized (and much less toxic) NH_4^+, and long-term exposure to this compound would be unlikely, as retardants are not repeatedly applied to one location (unlike their use as common fertilizers), flowing water in a stream would continually increase their lengthwise dispersal in a stream (and therefore continuously dilute a single application), and environmental degradation and use by aquatic vegetation and algae (as nutrients) would further decrease their presence in the aquatic system.

Risks to Freshwater Mussels from Ammonia

Augspurger et al. (2003) evaluated available data on the toxicity of ammonia to genera of freshwater mussels, and developed a recommendation for a water quality criterion of 0.3 to 1.0 mg/L total ammonia (as nitrogen) at pH 8 to protect these species. Evaluating the estimated water concentrations of the ammonium-containing compounds (see Appendix A) against these criteria, including the very conservative simplifying assumption that *all* nitrogen is present as ammonia, runoff from retardant-treated areas is not expected to result in water concentrations that would pose a risk to freshwater mussels. However, as with other aquatic species, an accidental spill (particularly in a small stream) would likely result in mortality to mussels.

4.2 Phytotoxicity

A field study (Larson and Newton 1996) examined the effect of a retardant that is no longer commercially available (containing monoammonium phosphate and diammonium sulfate), applied at a rate of 1 gpc, on vegetation in a North Dakota mixed grass prairie. In each test area, four plots were evaluated: a control, application of product only, application of product + burn, and burn only. The retardant application produced a notable increase in herbaceous biomass for the first growing season only, regardless of whether the plot was also burned, and caused no effects on shoot, leaf, or stem growth characteristics. This study's observations regarding species diversity effects are discussed in Section 4.3.

A follow-up study (Larson et al. 1999) evaluated the same retardant product when applied to Great Basin shrub steppe vegetation, in northern Nevada. Growth, resprouting, flowering, and incidence of galling insects were not affected by treatment with the retardant applied at a rate of 3 gpc. This study's observations regarding species diversity effects are also discussed in Section 4.3.

Shoot and whole plant death on individual plants were recorded following experimental application of a retardant that is no longer commercially available (containing diammonium sulfate, diammonium phosphate, and monoammonium phosphate) to plots on an Australian heathland (Bell 2003, Bell et al. 2005). Adverse effects varied by species, and increased with increasing application rate (from 0.5 to 1.5 liters mixed retardant per square meter, or 1.2 to 3.7 gpc). However, there was little change in visual estimates of percent foliar cover between treated and untreated areas.

Few studies have evaluated the potential effects of fire retardants on terrestrial vegetation. Overall, they indicate the possibility of phytotoxic effects to individual plants of more sensitive species at the application rates typically used, but generate no expectation of widespread or enduring impacts. Visible browning of leaves—possibly related to chemical burn caused by direct application of an ammonium-based product as well as dehydration of the leaf surface from exposure to the elevated salt content of the fire retardant—has been documented in field studies by Larson and Newton (1996); however, regeneration of leaf material was recorded later in the same growing season and herbivory was not affected.

4.3 Vegetation Diversity

Information on the effects of fire retardant chemicals on vegetation diversity is extremely limited. Larson et al. (1999) suggested that many effects of ammonium-based retardants can be anticipated based on studies with fertilizers. Similar to the effects of fertilizers, fire retardants may encourage growth of some plant species and giving them a competitive advantage over others, thus resulting in changes in community composition and species diversity (Tilman 1987, Wilson and Shay 1990). Bell et al. (2005) recorded enhanced weed invasion in an Australian heathland ecosystem, particularly in areas receiving high concentrations of a retardant that is no longer commercially available (containing diammonium sulfate, diammonium phosphate, and monoammonium phosphate). The effects of a retardant that is no longer commercially available (containing monoammonium phosphate and diammonium sulfate) were also evaluated in a North

Dakota grassland community (Larson and Newton 1996) and in a shrub steppe area in the Great Basin in Nevada (Larson et al. 1999). The researchers measured community characteristics, including species richness, evenness, diversity, and number of stems of woody and herbaceous plants.

- In the North Dakota prairie ecosystem, species richness was reduced in plots exposed to retardant regardless of whether the plot was burned or unburned. All plots were dominated by *Poa pratensis*, which clearly gained a competitive advantage from retardant application and crowded out other species.

- Investigations in the Great Basin shrub steppe ecosystem also showed that plots treated with fire chemicals experienced initial declines in species richness; however, differences among plots were undetectable after a year. Depression of species richness was most pronounced in the riparian corridor.

Overall, vegetative community response to burning was more dramatic than was the response to chemical application. In both studies, the authors note that each study was short-term, and that long-term ecological responses should be measured over several growing seasons. However, they did recommend that managers intending to use these chemicals to control prescribed burns should consider the effects on species richness or on individual species of concern (invasive species) when they evaluate management objectives on a landscape scale.

In an evaluation of the application of Phos-Chek XA fire retardant (containing diammonium phosphate) that was applied to a California grassland during the course of fighting a wildland fire, Larson and Duncan (1982) studied the effects on vegetative productivity. The two-year study reported that application of the retardant produced almost twice the yield of forage in the first year after application in both burned and unburned areas; this relative increase continued into the second year for the unburned treated plot. In the second year, there was no statistically significant increase in forage production in either the treated or untreated burned plots compared to the unburned, untreated control area. The authors reported that, although forbs usually increase in annual grassland after a fire, nitrogen fertilizer favors grasses, which dominated the first year after the fire. Forbs dominated the second year.

Although the phytotoxic effects and vegetation diversity endpoints in this analysis have underlying links related to mechanisms of toxicity (for example, varying susceptibility to effects on seed germination among plant species), further exhaustive or quantitative analysis of the topic is not warranted, since only limited areas are treated with these products and the vegetation would otherwise be severely affected by the fire itself in the absence of their use.

4.4 Risk Management Considerations

The type, severity, and likelihood of potential risks from use of chemical products to fight wildland fires are discussed in the previous sections of this chapter. The *probability* of their use to suppress a specific wildland fire depends on (1) whether the fire will be suppressed, and, if it will be suppressed, (2) whether chemical products are appropriate to the situation.

4.4.1 Suppression Decision-Making

The 2009 *Guidance for Implementation of Federal Wildland Fire Management Policy* categorizes wildland fires into two distinct types) (USFS / DOI 2009):

- Wildfires – unplanned ignitions or prescribed fires that are declared wildfires
- Prescribed fires – planned ignitions

As stated in that policy, "A wildland fire may be concurrently managed for one or more objectives and objectives can change as the fire spreads across the landscape. Objectives are affected by changes in fuels, weather, topography; varying social understanding and tolerance; and involvement of other governmental jurisdictions having different missions and objectives. Management response to a wildland fire on federal land is based on objectives established in the applicable Land / Resource Management Plan [L/RMP] and/or the Fire Management Plan... The L/RMP will define and identify fire's role in the ecosystem. The response to an ignition is guided by the strategies and objectives outlined in the L/RMP and/or the Fire Management Plan."

In determining the response to a wildland fire, the policy states that "Fire, as a critical natural process, will be integrated into land and resource management plans and activities on a landscape scale, and across agency boundaries. Response to wildland fires is based on ecological, social and legal consequences of the fire. The circumstances under which a fire occurs, and the likely consequences on firefighter and public safety and welfare, natural and cultural resources, and, values to be protected, dictate the appropriate response to the fire... Responses to wildland fires will be coordinated across jurisdictional boundaries."

4.4.2 Use of Chemical Products in Fire Suppression Actions

Use of chemical products to fight a wildland fire is determined on a case-by-case basis, by the responsible official for that particular incident. Environmental considerations are included in the decision-making process: environmental guidelines for use of suppression chemicals are integrated into Chapter 12 of *Interagency Standards for Fire and Fire Aviation Operations*, also known as the "Red Book" (NIFC 2020).

4.5 Uncertainties

Analysis of the uncertainty in an ecological risk assessment is an integral part of analyses conducted under EPA's guidelines (EPA 1998). The results presented in this risk assessment depend on a number of factors, including the availability of pertinent scientific information, standard risk assessment practices, exposure assumptions, and toxicity assumptions. Uncertainties are introduced into a risk assessment because a range of values could be used for each assumption. In general, most assumptions were selected to be representative of typical conditions, while a certain few assumptions (such as no environmental degradation to less toxic chemicals) were selected to avoid underestimating risks. Uncertainty is introduced into the ecological risk assessment process in both the problem formulation and analysis stages.

Uncertainties in problem formulation are manifested in the quality of conceptual models (EPA 1998). During problem formulation, the original development of the conceptual model could neglect risks that do exist but are not recognized, or could overemphasize risks that are relatively minor. The lack of available data with which to consistently evaluate sublethal effects for all ingredients/products is one example. In contrast, the conceptual model's characterization of environmental transport pathways and potential routes of fire-fighting chemical exposure to wildlife and aquatic species are reasonably unambiguous, as depicted in Figure 2-1.

In the analysis phase, several sources of uncertainty arise, including selection of receptors; exposure of receptors; data variability regarding the toxicity of the products, their ingredients, and the toxicity of the resulting mixture; and the assumptions made in defining the ecoregion characteristics. The sources of uncertainty and their effect on the risk conclusions are summarized below:

- In terms of the utility of the risk assessment conclusions for nationwide decision-making, the selection of the representative species that were evaluated introduces significant uncertainty into the conclusions. The species that were evaluated were carefully selected with this issue in mind, to provide a basic level of risk information for a wide range of wildlife, including mammals and bird species with a range of dietary/foraging characteristics and body sizes, fish, aquatic invertebrates, and amphibian tadpoles. Risks to other animals such as reptiles and terrestrial stages of amphibians were not assessed, since there were little to no toxicity data available for many of the ingredients in the fire-fighting chemical products for them. The resulting set of risk conclusions provides a general perspective on potential risks to wildlife, with the uncertainty in actual risk to a species growing with decreasing similarity to the species that were evaluated as representative species in the analysis.

- The actual exposure of any particular animal to the chemicals could, and likely will, vary from the exposures assumed in this assessment:

  - For terrestrial species, dietary and drinking water doses could vary from (a) none, if an animal's ingestion in an unevenly contaminated area resulted in chance or deliberate avoidance of food and water sources containing residues; to (b) 100%, which would result in estimated doses and risks as much as 80 times higher for animals with wide or limited foraging ranges, respectively. (Current dose estimates reflect assumptions about the fraction of an animal's diet that was assumed to be contaminated; see Section 3.2.1.1.)

  - This uncertainty is further complicated by actual variation in residue levels in or on contaminated food items and water. The levels were estimated based on well-validated models, but necessarily assumed uniform application rate of the chemicals over the drop area, which is not consistent with actual use, but will average out over larger areas. The impact of this issue on the total uncertainty is likely minimal. Additional sources of ingestion exposure that were not considered in this assessment could also occur, including incidental soil ingestion (such as from preening / grooming behavior) and ingestion of contaminated sediment entrained in aquatic prey species.

   - For aquatic species, the length of exposure to a chemical concentration in water will significantly affect the toxicity associated with that exposure. Generally, if the time period of exposure is longer, the concentration that can be tolerated is lower, and vice versa. In this analysis, the most conservative short-term LC_{50} was selected for each chemical, regardless of actual duration of the toxicity test. Thus, the LC_{50}s that were used are based on exposure durations that range from 1 hour to more than 10 days. To estimate risks, these LC_{50}s were compared to water concentrations of generally short duration. The risks were based on the initial, instantaneous water concentrations in streams, which would quickly decrease as a result of longitudinal dispersion and possible sediment sorption and degradation. In addition, no scenarios for the potential for aquatic organisms to avoid exposure were introduced into the calculation of risk. This could lead to a generally minimal to moderate overestimate in the predicted risk.

- When more than one toxicity data source was identified, the most conservative value (the value associated with the greatest toxicity) was selected for use in the risk assessment. This could lead to overestimates in the predicted risk.

- The interactions of the various ingredients in a product could enhance or decrease the toxicity of any one ingredient. In accordance with EPA guidance, additive toxicity was assumed in the absence of the data to the contrary. For terrestrial species, the estimated risk from additive toxicity of the ingredient combinations in the products was compared to the risks based on toxicity data reported in tests on the product mixtures; this comparison was made for terrestrial species. Reasonably consistent results indicated that the additivity assumption has resulted in minimal uncertainty in the risk conclusions.

- Terrestrial or aquatic wildlife could be exposed to multiple products if aircraft come from different bases, which may occur during high fire activity. This circumstance was not assessed in this risk assessment due to the great variability in combinations of products; however, it would be assumed that any toxicity would be additive.

- Fire-fighting chemicals can be used anywhere that a wildland fire occurs. The physical, chemical, and biological attributes of the natural system in which the chemicals are deposited will have a great impact on the environmental transport and fate of chemicals in that system, including the concentration of chemicals in water, soil, or as residues on terrestrial species diet items. Fifteen representative ecoregions were modeled in the analysis; actual areas into which fire-fighting chemicals are deposited will differ in some or all of these details. This introduces a significant level of uncertainty into the risk conclusions, which may be associated with either an underestimate or an overestimate of risk at a real-world location.

- For all scenarios, the analysis assumed no degradation of the chemicals to less toxic forms. This assumption was made since no minimum timeframe could be assured between chemical use and ecological exposure, and also since studies of retardant degradation on various substrates have shown that the relationship between toxicity to aquatic species and elapsed time is complex, indicating that multiple factors affect the resulting toxicity. This assumption of no degradation, for purposes of the analysis, may be associated with overestimates of risk to terrestrial and aquatic species, and also with further uncertainty regarding the potential for enhancement of invasive species' spread and corresponding decline in native species.

Table 4-7 summarizes these key sources of uncertainty and their potential significance for the risk conclusions presented in this assessment.

Table 4-7. Summary of Key Uncertainties

Source of Uncertainty	Direction [a,b]	Magnitude [b,c]	Comment
Risk exists but is not assessed.	+/−	2	The availability of toxicity data limits the ability to evaluate issues (such as sublethal effects) for all ingredients/products.
Other significant environmental and/or exposure pathways exist but were not assessed.	+/−	0	Pathways of exposure are relatively unambiguous.
Use of representative species as receptors.	+/−	2	Data availability and model simplification required this approach.
Terrestrial species food item contamination frequency.	+/−	2	Could vary from 0 to 10 times the modeled amount.
Chemical residues in/on terrestrial species food and water.	+/−	1	Models used are well-validated, but actual chemical coverage is not uniform.
Duration of aquatic species' exposure compared to duration of toxicity testing.	+	2	In most cases, exposure duration would be far less than the test duration.
Initial water concentrations were used instead of a time-weighted average or other downward adjustment (such as decrease due to sorption, dispersion).	+	2	Initial concentrations were used since exposure could occur at any time after application.
Most conservative toxicity value used for each chemical.	+	1	This avoided underestimating toxicity.
Additive toxicity was assumed for ingredient mixtures.	+/−	0	Risks from ingredient-specific vs. whole-product toxicity data were consistent.
Use of representative ecoregions.	+/−	3	Attributes of natural systems where chemicals are used will likely differ in one or more respects from those that were modeled.
Environmental degradation to less toxic forms of ingredients was not included in the model.	+	2	Exposure could occur at any time after application.

[a] Direction of effect on risk calculations: "+" may result in risks that are overly conservative; "−" may result in risks that are underestimated.
[b] Direction and magnitude values based on professional judgment.
[c] Magnitude of effect on risk calculations: 0 = negligible, 1 = small, 2 = medium, 3 = large.

5.0 REFERENCES

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Appendix A

Ecological Risk Assessments for Retardants on Qualified Products List

June 2020

Product	Formulation ID Number(s) Evaluated in Risk Assessment	
Phos-Chek MVP-Fx	0439-014A	0439-014B
Phos-Chek MVP-F	0403-014A	0403-014B
Phos-Chek 259-Fx	0439-091B	
Phos-Chek LC-95A-R	1051695-C	1051695-A
Phos-Chek LC-95A-Fx	0439-076B	
Phos-Chek LC-95A-F	0381-045C	0381-045D
Phos-Chek LC-95-W	0381-090B	

Scientific notation: Some of the risk tables in this section use scientific notation, since many of the values are very small. For example, the notation 3.63E-001 represents 3.63×10^{-1}, or 0.363. Similarly, 4.65E-009 represents 4.65×10^{-9}, or 0.00000000465.

Shaded cells in these tables indicate the exposures that are predicted to present a risk to sensitive species.

Shaded and boldfaced entries indicate a risk to both non-sensitive and sensitive species.

NA = not applicable.
ND = no data.

Phos-Chek MVP-Fx (0439-014A)

Product Data

Concentrate form:	Powder	
Mix ratio:	0.96	pounds per gallon
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation LC_{50} (mg/L):	2,183	(Rainbow trout, 96 hours)
Mixture application rate:	0.06	gal/ft^2

Estimated Risks to Terrestrial Species: Product

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	1.99E-03	1.59E-04	1.99E-02	4.32E-03	1.05E-03	1.00E-02	1.15E-02	4.52E-03
2	3.98E-03	3.19E-04	3.99E-02	8.64E-03	2.10E-03	2.01E-02	2.30E-02	9.05E-03
3	5.96E-03	4.78E-04	5.98E-02	1.30E-02	3.16E-03	3.01E-02	3.45E-02	1.36E-02
4	7.95E-03	6.38E-04	7.98E-02	1.73E-02	4.21E-03	4.01E-02	4.60E-02	1.81E-02
6	1.19E-02	9.57E-04	1.20E-01	2.59E-02	6.31E-03	6.02E-02	6.90E-02	2.71E-02

Estimated Risks to Terrestrial Species: Additive Risk Based on Ingredients Screened into Analysis

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	1.66E-03	1.33E-04	1.67E-02	3.40E-03	8.24E-04	8.38E-03	9.61E-03	3.78E-03
2	3.32E-03	2.66E-04	3.33E-02	6.81E-03	1.65E-03	1.68E-02	1.92E-02	7.56E-03
3	4.98E-03	4.00E-04	5.00E-02	1.02E-02	2.47E-03	2.51E-02	2.88E-02	1.13E-02
4	6.64E-03	5.33E-04	6.67E-02	1.36E-02	3.30E-03	3.35E-02	3.84E-02	1.51E-02
6	9.97E-03	7.99E-04	1.00E-01	2.04E-02	4.94E-03	5.03E-02	5.76E-02	2.27E-02

Summary of Risks to Aquatic Species

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
331: Great Plains-Palouse dry steppe (1)												
	3.55E-06	3.52E-06	4.98E-08	1.50E-07	1.48E-07	2.10E-09	2.21E-02	1.46E-02	9.49E-03	3.09E-03	2.04E-03	1.32E-03
M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow (2)												
	4.42E-06	4.38E-06	5.66E-08	1.57E-07	1.56E-07	2.01E-09	4.43E-02	2.93E-02	1.90E-02	6.17E-03	4.09E-03	2.65E-03
M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow (2)												
	1.98E-05	1.97E-05	1.08E-07	8.19E-07	8.16E-07	4.47E-09	4.43E-02	2.93E-02	1.90E-02	6.17E-03	4.09E-03	2.65E-03
M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow (2)												
	2.57E-04	2.55E-04	2.91E-06	1.09E-05	1.09E-05	1.24E-07	4.43E-02	2.93E-02	1.90E-02	6.17E-03	4.09E-03	2.65E-03
242: Pacific lowland mixed forest (2)												
	2.04E-04	2.04E-04	1.44E-07	8.83E-06	8.83E-06	6.24E-09	4.43E-02	2.93E-02	1.90E-02	6.17E-03	4.09E-03	2.65E-03
234: Lower Mississippi riverine forest (2)												
	2.05E-05	2.05E-05	1.86E-08	7.09E-07	7.09E-07	6.44E-10	4.43E-02	2.93E-02	1.90E-02	6.17E-03	4.09E-03	2.65E-03
M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow (2)												
	1.49E-04	1.49E-04	1.38E-07	5.36E-06	5.35E-06	4.94E-09	4.43E-02	2.93E-02	1.90E-02	6.17E-03	4.09E-03	2.65E-03

Summary of Risks to Aquatic Species (continued)

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			***Large Stream***			***Small Stream***			***Large Stream***		
	Rainbow Trout	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	**Daphnia magna**	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
231: Southeastern mixed forest (2)	1.45E-08	5.07E-09	1.29E-08	6.27E-10	2.20E-10	5.58E-10	4.43E-02	2.93E-02	1.90E-02	6.17E-03	4.09E-03	2.65E-03
342: Intermountain semi-desert (3)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.64E-02	4.39E-02	2.85E-02	9.26E-03	6.13E-03	3.97E-03
315: Southwest plateau and plains dry steppe and shrub (3)	6.24E-05	6.23E-05	1.76E-07	2.15E-06	2.15E-06	6.06E-09	6.64E-02	4.39E-02	2.85E-02	9.26E-03	6.13E-03	3.97E-03
212: Laurentian mixed forest (4)	2.57E-04	2.57E-04	2.28E-07	9.24E-06	9.23E-06	8.18E-09	8.85E-02	5.86E-02	3.80E-02	1.23E-02	8.17E-03	5.29E-03
M242: Cascade mixed forest–coniferous forest–alpine meadow (4)	4.93E-04	4.92E-04	6.20E-08	1.72E-05	1.72E-05	2.17E-09	8.85E-02	5.86E-02	3.80E-02	1.23E-02	8.17E-03	5.29E-03
232: Outer coastal plain mixed forest (6)	1.76E-05	1.76E-05	8.55E-10	6.09E-07	6.09E-07	2.96E-11	1.33E-01	8.79E-02	5.70E-02	1.85E-02	1.23E-02	7.94E-03
131: Yukon intermontane plateaus taiga (6)	9.80E-03	9.73E-03	6.32E-05	3.51E-04	3.49E-04	2.26E-06	1.33E-01	8.79E-02	5.70E-02	1.85E-02	1.23E-02	7.94E-03
M262: California coastal range open woodland–shrub–coniferous forest–meadow (6)	1.96E-05	1.96E-05	6.94E-09	8.07E-07	8.07E-07	2.86E-10	1.33E-01	8.79E-02	5.70E-02	1.85E-02	1.23E-02	7.94E-03

Risks to Aquatic Species from Accidental Spills

	Estimated Risk Quotient					
	Small Stream			*Large Stream*		
Spill Type	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
Bulk Powdered Retardant	**3.52E+01**	**2.32E+01**	**1.52E+01**	**1.21E+00**	**7.96E-01**	**5.20E-01**
Wet Retardant Concentrate	NA	NA	NA	NA	NA	NA
Tank-Mixed Retardant	**1.18E+01**	**6.56E+02**	**5.05E+00**	4.04E-01	2.67E-01	1.73E-01

Phos-Chek MVP-Fx (0439-014B)

Product Data

Concentrate form:	Powder	
Mix ratio:	0.96	pounds per gallon
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation LC_{50} (mg/L):	2,024	(Rainbow trout, 96 hours)
Mixture application rate:	0.06	gal/ft^2

Estimated Risks to Terrestrial Species: Product

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	1.99E-03	1.59E-04	1.99E-02	4.32E-03	1.05E-03	1.00E-02	1.15E-02	4.52E-03
2	3.98E-03	3.19E-04	3.99E-02	8.64E-03	2.10E-03	2.01E-02	2.30E-02	9.05E-03
3	5.96E-03	4.78E-04	5.98E-02	1.30E-02	3.16E-03	3.01E-02	3.45E-02	1.36E-02
4	7.95E-03	6.38E-04	7.98E-02	1.73E-02	4.21E-03	4.01E-02	4.60E-02	1.81E-02
6	1.19E-02	9.57E-04	1.20E-01	2.59E-02	6.31E-03	6.02E-02	6.90E-02	2.71E-02

Estimated Risks to Terrestrial Species: Additive Risk Based on Ingredients Screened into Analysis

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	2.60E-03	2.09E-04	2.61E-02	3.60E-03	8.24E-04	1.31E-02	1.50E-02	5.92E-03
2	5.20E-03	4.17E-04	5.22E-02	7.19E-03	1.65E-03	2.62E-02	3.01E-02	1.18E-02
3	7.80E-03	6.26E-04	7.83E-02	1.08E-02	2.47E-03	3.94E-02	4.51E-02	1.78E-02
4	1.04E-02	8.34E-04	1.04E-01	1.44E-02	3.30E-03	5.25E-02	6.02E-02	2.37E-02
6	1.56E-02	1.25E-03	1.57E-01	2.16E-02	4.94E-03	7.87E-02	9.02E-02	3.55E-02

Summary of Risks to Aquatic Species

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
331: Great Plains-Palouse dry steppe (1)												
	3.36E-06	3.33E-06	4.98E-08	1.42E-07	1.40E-07	2.10E-09	2.13E-02	1.38E-02	9.49E-03	2.97E-03	1.93E-03	1.32E-03
M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow (2)												
	4.06E-06	4.02E-06	5.66E-08	1.44E-07	1.43E-07	2.01E-09	4.26E-02	2.76E-02	1.90E-02	5.94E-03	3.85E-03	2.65E-03
M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow (2)												
	1.82E-05	1.81E-05	1.08E-07	7.52E-07	7.49E-07	4.47E-09	4.26E-02	2.76E-02	1.90E-02	5.94E-03	3.85E-03	2.65E-03
M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow (2)												
	2.36E-04	2.34E-04	2.91E-06	1.00E-05	9.96E-06	1.24E-07	4.26E-02	2.76E-02	1.90E-02	5.94E-03	3.85E-03	2.65E-03
242: Pacific lowland mixed forest (2)												
	1.87E-04	1.87E-04	1.44E-07	8.11E-06	8.10E-06	6.24E-09	4.26E-02	2.76E-02	1.90E-02	5.94E-03	3.85E-03	2.65E-03
234: Lower Mississippi riverine forest (2)												
	1.88E-05	1.88E-05	1.86E-08	6.50E-07	6.50E-07	6.44E-10	4.26E-02	2.76E-02	1.90E-02	5.94E-03	3.85E-03	2.65E-03
M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow (2)												
	1.22E-07	4.57E-08	1.38E-07	4.39E-09	1.64E-09	4.94E-09	2.29E-02	7.88E-03	1.90E-02	3.19E-03	1.10E-03	2.65E-03

Summary of Risks to Aquatic Species (continued)

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
231: Southeastern mixed forest (2)												
	1.45E-08	5.07E-09	1.29E-08	6.27E-10	2.20E-10	5.58E-10	4.26E-02	2.76E-02	1.90E-02	5.94E-03	3.85E-03	2.65E-03
342: Intermountain semi-desert (3)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.39E-02	4.14E-02	2.85E-02	8.91E-03	5.78E-03	3.97E-03
315: Southwest plateau and plains dry steppe and shrub (3)												
	5.76E-05	5.75E-05	1.76E-07	1.99E-06	1.98E-06	6.06E-09	6.39E-02	4.14E-02	2.85E-02	8.91E-03	5.78E-03	3.97E-03
212: Laurentian mixed forest (4)												
	2.36E-04	2.35E-04	2.28E-07	8.46E-06	8.46E-06	8.18E-09	8.52E-02	5.52E-02	3.80E-02	1.19E-02	7.70E-03	5.29E-03
M242: Cascade mixed forest–coniferous forest–alpine meadow (4)												
	4.51E-04	4.51E-04	6.20E-08	1.58E-05	1.58E-05	2.17E-09	8.52E-02	5.52E-02	3.80E-02	1.19E-02	7.70E-03	5.29E-03
232: Outer coastal plain mixed forest (6)												
	1.63E-05	1.63E-05	8.55E-10	5.63E-07	5.63E-07	2.96E-11	1.28E-01	8.29E-02	5.70E-02	1.78E-02	1.16E-02	7.94E-03
131: Yukon intermontane plateaus taiga (6)												
	9.07E-03	8.99E-03	6.32E-05	3.25E-04	3.22E-04	2.26E-06	1.28E-01	8.29E-02	5.70E-02	1.78E-02	1.16E-02	7.94E-03
M262: California coastal range open woodland–shrub–coniferous forest–meadow (6)												
	1.81E-05	1.81E-05	6.94E-09	7.46E-07	7.46E-07	2.86E-10	1.28E-01	8.29E-02	5.70E-02	1.78E-02	1.16E-02	7.94E-03

Risks to Aquatic Species from Accidental Spills

	Estimated Risk Quotient					
	Small Stream			*Large Stream*		
Spill Type	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
Bulk Powdered Retardant	**3.40E+01**	**2.21E+01**	**1.52E+01**	**1.17E+00**	**7.56E-01**	**5.20E-01**
Wet Retardant Concentrate	NA	NA	NA	NA	NA	NA
Tank-Mixed Retardant	**1.13E+01**	**6.56E+02**	**5.05E+00**	3.89E-01	2.52E-01	1.73E-01

Phos-Chek MVP-F (0403-014A)

Product Data

Concentrate form:	Powder	
Mix ratio:	0.95	pounds per gallon
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation LC_{50} (mg/L):	2,454	(Rainbow trout, 96 hours)
Mixture application rate:	0.06	gal/ft^2

Estimated Risks to Terrestrial Species: Product

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	1.97E-03	1.58E-04	1.97E-02	4.28E-03	1.04E-03	9.93E-03	1.14E-02	4.48E-03
2	3.93E-03	3.16E-04	3.95E-02	8.55E-03	2.08E-03	1.99E-02	2.28E-02	8.95E-03
3	5.90E-03	4.73E-04	5.92E-02	1.28E-02	3.12E-03	2.98E-02	3.41E-02	1.34E-02
4	7.87E-03	6.31E-04	7.90E-02	1.71E-02	4.16E-03	3.97E-02	4.55E-02	1.79E-02
6	1.18E-02	9.47E-04	1.18E-01	2.57E-02	6.25E-03	5.96E-02	6.83E-02	2.69E-02

Estimated Risks to Terrestrial Species: Additive Risk Based on Ingredients Screened into Analysis

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	1.56E-03	1.25E-04	1.56E-02	3.39E-03	8.25E-04	7.86E-03	9.01E-03	3.55E-03
2	3.12E-03	2.50E-04	3.13E-02	6.77E-03	1.65E-03	1.57E-02	1.80E-02	7.09E-03
3	4.67E-03	3.75E-04	4.69E-02	1.02E-02	2.47E-03	2.36E-02	2.70E-02	1.06E-02
4	6.23E-03	5.00E-04	6.25E-02	1.35E-02	3.30E-03	3.14E-02	3.60E-02	1.42E-02
6	9.35E-03	7.50E-04	9.38E-02	2.03E-02	4.95E-03	4.72E-02	5.41E-02	2.13E-02

Summary of Risks to Aquatic Species

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
331: Great Plains-Palouse dry steppe (1)												
	5.26E-08	1.88E-08	5.04E-08	2.21E-09	7.91E-10	2.12E-09	1.16E-02	3.98E-03	9.60E-03	1.61E-03	5.56E-04	1.34E-03
M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow (2)												
	6.02E-08	2.14E-08	5.72E-08	2.14E-09	7.63E-10	2.04E-09	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03
M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow (2)												
	1.08E-07	3.90E-08	1.09E-07	4.46E-09	1.62E-09	4.52E-09	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03
M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow (2)												
	2.85E-06	1.04E-06	2.94E-06	1.21E-07	4.41E-08	1.25E-07	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03
242: Pacific lowland mixed forest (2)												
	1.54E-07	5.47E-08	1.46E-07	6.67E-09	2.37E-09	6.31E-09	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03
234: Lower Mississippi riverine forest (2)												
	1.77E-08	6.49E-09	1.88E-08	6.11E-10	2.25E-10	6.52E-10	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03
M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow (2)												
	1.24E-07	4.62E-08	1.39E-07	4.44E-09	1.66E-09	5.00E-09	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03

Summary of Risks to Aquatic Species (continued)

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
231: Southeastern mixed forest (2)	1.46E-08	5.13E-09	1.30E-08	6.34E-10	2.22E-10	5.64E-10	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03
342: Intermountain semi-desert (3)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.47E-02	1.20E-02	2.88E-02	4.83E-03	1.67E-03	4.02E-03
315: Southwest plateau and plains dry steppe and shrub (3)	1.75E-07	6.34E-08	1.78E-07	6.03E-09	2.19E-09	6.13E-09	3.47E-02	1.20E-02	2.88E-02	4.83E-03	1.67E-03	4.02E-03
212: Laurentian mixed forest (4)	2.04E-07	7.63E-08	2.30E-07	7.34E-09	2.74E-09	8.27E-09	4.62E-02	1.59E-02	3.84E-02	6.45E-03	2.22E-03	5.35E-03
M242: Cascade mixed forest–coniferous forest–alpine meadow (4)	5.06E-08	1.94E-08	6.27E-08	1.77E-09	6.80E-10	2.19E-09	4.62E-02	1.59E-02	3.84E-02	6.45E-03	2.22E-03	5.35E-03
232: Outer coastal plain mixed forest (6)	7.37E-10	2.78E-10	8.65E-10	2.55E-11	9.63E-12	2.99E-11	6.93E-02	2.39E-02	5.76E-02	9.67E-03	3.33E-03	8.03E-03
131: Yukon intermontane plateaus taiga (6)	1.05E-04	3.40E-05	6.39E-05	3.77E-06	1.22E-06	2.29E-06	6.93E-02	2.39E-02	5.76E-02	9.67E-03	3.33E-03	8.03E-03
M262: California coastal range open woodland–shrub–coniferous forest–meadow (6)	6.16E-09	2.31E-09	7.02E-09	2.54E-10	9.51E-11	2.90E-10	6.93E-02	2.39E-02	5.76E-02	9.67E-03	3.33E-03	8.03E-03

Risks to Aquatic Species from Accidental Spills

	Estimated Risk Quotient					
	Small Stream			*Large Stream*		
Spill Type	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
Bulk Powdered Retardant	**1.85E+01**	**6.36E+00**	**1.53E+01**	**6.33E-01**	2.18E-01	**5.25E-01**
Wet Retardant Concentrate	NA	NA	NA	NA	NA	NA
Tank-Mixed Retardant	**6.15E+00**	**6.62E+02**	**5.11E+00**	2.11E-01	7.27E-02	1.75E-01

Phos-Chek MVP-F (0403-014B)

Product Data

Concentrate form:	Powder	
Mix ratio:	0.95	pounds per gallon
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation LC_{50} (mg/L):	1,845	(Rainbow trout, 96 hours)
Mixture application rate:	0.06	gal/ft^2

Estimated Risks to Terrestrial Species: Product

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	1.97E-03	1.58E-04	1.97E-02	4.28E-03	1.04E-03	9.93E-03	1.14E-02	4.48E-03
2	3.93E-03	3.16E-04	3.95E-02	8.55E-03	2.08E-03	1.99E-02	2.28E-02	8.95E-03
3	5.90E-03	4.73E-04	5.92E-02	1.28E-02	3.12E-03	2.98E-02	3.41E-02	1.34E-02
4	7.87E-03	6.31E-04	7.90E-02	1.71E-02	4.16E-03	3.97E-02	4.55E-02	1.79E-02
6	1.18E-02	9.47E-04	1.18E-01	2.57E-02	6.25E-03	5.96E-02	6.83E-02	2.69E-02

Estimated Risks to Terrestrial Species: Additive Risk Based on Ingredients Screened into Analysis

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	1.56E-03	1.25E-04	1.56E-02	3.39E-03	8.25E-04	7.86E-03	9.01E-03	3.55E-03
2	3.12E-03	2.50E-04	3.13E-02	6.77E-03	1.65E-03	1.57E-02	1.80E-02	7.09E-03
3	4.67E-03	3.75E-04	4.69E-02	1.02E-02	2.47E-03	2.36E-02	2.70E-02	1.06E-02
4	6.23E-03	5.00E-04	6.25E-02	1.35E-02	3.30E-03	3.14E-02	3.60E-02	1.42E-02
6	9.35E-03	7.50E-04	9.38E-02	2.03E-02	4.95E-03	4.72E-02	5.41E-02	2.13E-02

Summary of Risks to Aquatic Species

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
331: Great Plains-Palouse dry steppe (1)												
	5.26E-08	1.88E-08	5.04E-08	2.21E-09	7.91E-10	2.12E-09	1.16E-02	3.98E-03	9.60E-03	1.61E-03	5.56E-04	1.34E-03
M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow (2)												
	6.02E-08	2.14E-08	5.72E-08	2.14E-09	7.63E-10	2.04E-09	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03
M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow (2)												
	1.08E-07	3.90E-08	1.09E-07	4.46E-09	1.62E-09	4.52E-09	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03
M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow (2)												
	2.85E-06	1.04E-06	2.94E-06	1.21E-07	4.41E-08	1.25E-07	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03
242: Pacific lowland mixed forest (2)												
	1.54E-07	5.47E-08	1.46E-07	6.67E-09	2.37E-09	6.31E-09	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03
234: Lower Mississippi riverine forest (2)												
	1.77E-08	6.49E-09	1.88E-08	6.11E-10	2.25E-10	6.52E-10	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03
M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow (2)												
	1.24E-07	4.62E-08	1.39E-07	4.44E-09	1.66E-09	5.00E-09	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03

Summary of Risks to Aquatic Species (continued)

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
231: Southeastern mixed forest (2)												
	1.46E-08	5.13E-09	1.30E-08	6.34E-10	2.22E-10	5.64E-10	2.31E-02	7.97E-03	1.92E-02	3.22E-03	1.11E-03	2.68E-03
342: Intermountain semi-desert (3)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.47E-02	1.20E-02	2.88E-02	4.83E-03	1.67E-03	4.02E-03
315: Southwest plateau and plains dry steppe and shrub (3)												
	1.75E-07	6.34E-08	1.78E-07	6.03E-09	2.19E-09	6.13E-09	3.47E-02	1.20E-02	2.88E-02	4.83E-03	1.67E-03	4.02E-03
212: Laurentian mixed forest (4)												
	2.04E-07	7.63E-08	2.30E-07	7.34E-09	2.74E-09	8.27E-09	4.62E-02	1.59E-02	3.84E-02	6.45E-03	2.22E-03	5.35E-03
M242: Cascade mixed forest–coniferous forest–alpine meadow (4)												
	5.06E-08	1.94E-08	6.27E-08	1.77E-09	6.80E-10	2.19E-09	4.62E-02	1.59E-02	3.84E-02	6.45E-03	2.22E-03	5.35E-03
232: Outer coastal plain mixed forest (6)												
	7.37E-10	2.78E-10	8.65E-10	2.55E-11	9.63E-12	2.99E-11	6.93E-02	2.39E-02	5.76E-02	9.67E-03	3.33E-03	8.03E-03
131: Yukon intermontane plateaus taiga (6)												
	1.05E-04	3.40E-05	6.39E-05	3.77E-06	1.22E-06	2.29E-06	6.93E-02	2.39E-02	5.76E-02	9.67E-03	3.33E-03	8.03E-03
M262: California coastal range open woodland–shrub–coniferous forest–meadow (6)												
	6.16E-09	2.31E-09	7.02E-09	2.54E-10	9.51E-11	2.90E-10	6.93E-02	2.39E-02	5.76E-02	9.67E-03	3.33E-03	8.03E-03

Risks to Aquatic Species from Accidental Spills

	Estimated Risk Quotient					
	Small Stream			***Large Stream***		
Spill Type	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
Bulk Powdered Retardant	**1.85E+01**	**6.36E+00**	**1.53E+01**	**6.33E-01**	2.18E-01	**5.25E-01**
Wet Retardant Concentrate	NA	NA	NA	NA	NA	NA
Tank-Mixed Retardant	**6.15E+00**	**6.62E+02**	**5.11E+00**	2.11E-01	7.27E-02	1.75E-01

Phos-Chek 259-Fx (0439-091B)

Product Data

Concentrate form:	Powder	
Mix ratio:	1.01	pounds per gallon
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation LC_{50} (mg/L):	860	(Rainbow trout, 96 hours)
Mixture application rate:	0.06	gal/ft^2

Estimated Risks to Terrestrial Species: Product

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	2.04E-03	1.63E-04	2.04E-02	4.42E-03	1.08E-03	1.03E-02	1.18E-02	4.63E-03
2	4.07E-03	3.27E-04	4.09E-02	8.85E-03	2.16E-03	2.05E-02	2.35E-02	9.27E-03
3	6.11E-03	4.90E-04	6.13E-02	1.33E-02	3.23E-03	3.08E-02	3.53E-02	1.39E-02
4	8.14E-03	6.53E-04	8.17E-02	1.77E-02	4.31E-03	4.11E-02	4.71E-02	1.85E-02
6	1.22E-02	9.80E-04	1.23E-01	2.65E-02	6.47E-03	6.16E-02	7.06E-02	2.78E-02

Estimated Risks to Terrestrial Species: Additive Risk Based on Ingredients Screened into Analysis

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	1.68E-03	1.35E-04	1.69E-02	3.45E-03	8.34E-04	8.48E-03	9.72E-03	3.82E-03
2	3.36E-03	2.70E-04	3.37E-02	6.89E-03	1.67E-03	1.70E-02	1.94E-02	7.65E-03
3	5.04E-03	4.04E-04	5.06E-02	1.03E-02	2.50E-03	2.54E-02	2.92E-02	1.15E-02
4	6.72E-03	5.39E-04	6.74E-02	1.38E-02	3.34E-03	3.39E-02	3.89E-02	1.53E-02
6	1.01E-02	8.09E-04	1.01E-01	2.07E-02	5.01E-03	5.09E-02	5.83E-02	2.29E-02

Summary of Risks to Aquatic Species

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
331: Great Plains-Palouse dry steppe (1)												
	3.43E-06	3.35E-06	2.86E-08	1.45E-07	1.42E-09	1.21E-09	3.85E-02	1.82E-02	5.45E-03	5.37E-03	2.54E-03	7.60E-04
M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow (2)												
	4.26E-06	4.17E-06	3.25E-08	1.52E-07	1.40E-09	1.16E-09	7.70E-02	3.64E-02	1.09E-02	1.07E-02	5.07E-03	1.52E-03
M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow (2)												
	1.89E-05	1.87E-05	6.20E-08	7.82E-07	3.01E-09	2.57E-09	7.70E-02	3.64E-02	1.09E-02	1.07E-02	5.07E-03	1.52E-03
M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow (2)												
	2.47E-04	2.43E-04	1.67E-06	1.05E-05	7.35E-08	7.12E-08	7.70E-02	3.64E-02	1.09E-02	1.07E-02	5.07E-03	1.52E-03
242: Pacific lowland mixed forest (2)												
	1.93E-04	1.93E-04	8.23E-08	8.39E-06	9.24E-09	3.57E-09	7.70E-02	3.64E-02	1.09E-02	1.07E-02	5.07E-03	1.52E-03
234: Lower Mississippi riverine forest (2)												
	1.95E-05	1.94E-05	1.07E-08	6.74E-07	7.44E-10	3.70E-10	7.70E-02	3.64E-02	1.09E-02	1.07E-02	5.07E-03	1.52E-03
M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow (2)												
	1.42E-04	1.42E-04	7.92E-08	5.08E-06	5.33E-09	2.84E-09	7.70E-02	3.64E-02	1.09E-02	1.07E-02	5.07E-03	1.52E-03

Summary of Risks to Aquatic Species (continued)

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
231: Southeastern mixed forest (2)												
	3.48E-08	9.95E-09	7.54E-09	1.51E-09	4.31E-10	3.26E-10	7.70E-02	3.64E-02	1.09E-02	1.07E-02	5.07E-03	1.52E-03
342: Intermountain semi-desert (3)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E-01	5.46E-02	1.64E-02	1.61E-02	7.61E-03	2.28E-03
315: Southwest plateau and plains dry steppe and shrub (3)												
	5.93E-05	5.91E-05	1.01E-07	2.05E-06	4.68E-09	3.48E-09	1.15E-01	5.46E-02	1.64E-02	1.61E-02	7.61E-03	2.28E-03
212: Laurentian mixed forest (4)												
	2.44E-04	2.44E-04	1.31E-07	8.77E-06	9.05E-09	4.70E-09	1.54E-01	7.28E-02	2.18E-02	2.15E-02	1.01E-02	3.04E-03
M242: Cascade mixed forest–coniferous forest–alpine meadow (4)												
	4.67E-04	4.67E-04	3.56E-08	1.63E-05	1.09E-08	1.25E-09	1.54E-01	7.28E-02	2.18E-02	2.15E-02	1.01E-02	3.04E-03
232: Outer coastal plain mixed forest (6)												
	1.67E-05	1.67E-05	4.94E-10	5.78E-07	3.70E-10	1.71E-11	2.31E-01	1.09E-01	3.27E-02	3.22E-02	1.52E-02	4.56E-03
131: Yukon intermontane plateaus taiga (6)												
	9.58E-03	9.31E-03	1.18E-04	3.43E-04	4.20E-06	4.22E-06	2.31E-01	1.09E-01	3.27E-02	3.22E-02	1.52E-02	4.56E-03
M262: California coastal range open woodland–shrub–coniferous forest–meadow (6)												
	1.86E-05	1.86E-05	4.00E-09	7.66E-07	5.97E-10	1.65E-10	2.31E-01	1.09E-01	3.27E-02	3.22E-02	1.52E-02	4.56E-03

Risks to Aquatic Species from Accidental Spills

Spill Type	Estimated Risk Quotient					
	Small Stream			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
Bulk Powdered Retardant	**6.08E+01**	**2.88E+01**	**8.62E+00**	**2.09E+00**	**9.86E-01**	2.96E-01
Wet Retardant Concentrate	NA	NA	NA	NA	NA	NA
Tank-Mixed Retardant	**2.05E+01**	**9.68E+00**	**2.90E+00**	**7.02E-01**	3.32E-01	9.95E-02

Phos-Chek LC-95A-R (1051695-C)

Product Data

Concentrate form:	Liquid	
Mix ratio:	1	gal concentrate / 5.5 gal water
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation LC_{50} (mg/L):	435	(Rainbow trout, 96 hours)
Mixture application rate:	0.06	gal/ft^2

Estimated Risks to Terrestrial Species: Product

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	3.85E-03	3.09E-04	3.87E-02	8.38E-03	2.04E-03	1.95E-02	2.23E-02	8.77E-03
2	7.71E-03	6.18E-04	7.74E-02	1.68E-02	4.08E-03	3.89E-02	4.46E-02	1.75E-02
3	1.16E-02	9.27E-04	1.16E-01	2.51E-02	6.12E-03	5.84E-02	6.69E-02	2.63E-02
4	1.54E-02	1.24E-03	1.55E-01	3.35E-02	8.16E-03	7.78E-02	8.92E-02	3.51E-02
6	2.31E-02	1.85E-03	2.32E-01	5.03E-02	1.22E-02	1.17E-01	1.34E-01	5.26E-02

Estimated Risks to Terrestrial Species: Additive Risk Based on Ingredients Screened into Analysis

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	6.11E-03	4.90E-04	6.13E-02	1.33E-02	3.23E-03	3.08E-02	3.53E-02	1.39E-02
2	1.22E-02	9.80E-04	1.23E-01	2.66E-02	6.47E-03	6.17E-02	7.07E-02	2.78E-02
3	1.83E-02	1.47E-03	1.84E-01	3.98E-02	9.70E-03	9.25E-02	1.06E-01	4.17E-02
4	2.44E-02	1.96E-03	2.45E-01	5.31E-02	1.29E-02	1.23E-01	1.41E-01	5.56E-02
6	3.67E-02	2.94E-03	3.68E-01	7.97E-02	1.94E-02	1.85E-01	2.12E-01	8.34E-02

Summary of Risks to Aquatic Species

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
331: Great Plains-Palouse dry steppe (1)												
	1.37E-08	2.16E-09	0.00E+00	5.78E-10	9.12E-11	0.00E+00	1.98E-02	3.13E-03	0.00E+00	2.76E-03	4.36E-04	0.00E+00
M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow (2)												
	1.91E-08	3.01E-09	0.00E+00	6.79E-10	1.07E-10	0.00E+00	3.96E-02	6.25E-03	0.00E+00	5.53E-03	8.72E-04	0.00E+00
M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow (2)												
	9.99E-09	1.58E-09	0.00E+00	4.14E-10	6.52E-11	0.00E+00	3.96E-02	6.25E-03	0.00E+00	5.53E-03	8.72E-04	0.00E+00
M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow (2)												
	1.11E-07	1.75E-08	0.00E+00	4.72E-09	7.44E-10	0.00E+00	3.96E-02	6.25E-03	0.00E+00	5.53E-03	8.72E-04	0.00E+00
242: Pacific lowland mixed forest (2)												
	3.95E-08	6.23E-09	0.00E+00	1.71E-09	2.70E-10	0.00E+00	3.96E-02	6.25E-03	0.00E+00	5.53E-03	8.72E-04	0.00E+00
234: Lower Mississippi riverine forest (2)												
	4.34E-09	6.85E-10	0.00E+00	1.69E-10	2.67E-11	0.00E+00	3.96E-02	6.25E-03	0.00E+00	5.53E-03	8.72E-04	0.00E+00
M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow (2)												
	7.28E-10	1.15E-10	0.00E+00	2.61E-11	4.11E-12	0.00E+00	3.96E-02	6.25E-03	0.00E+00	5.53E-03	8.72E-04	0.00E+00

Summary of Risks to Aquatic Species (continued)

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
231: Southeastern mixed forest (2)												
	1.28E-08	2.03E-09	0.00E+00	5.56E-10	8.77E-11	0.00E+00	3.96E-02	6.25E-03	0.00E+00	5.53E-03	8.72E-04	0.00E+00
342: Intermountain semi-desert (3)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.95E-02	9.38E-03	0.00E+00	8.29E-03	1.31E-03	0.00E+00
315: Southwest plateau and plains dry steppe and shrub (3)												
	2.20E-06	3.47E-07	0.00E+00	9.50E-08	1.50E-08	0.00E+00	5.95E-02	9.38E-03	0.00E+00	8.29E-03	1.31E-03	0.00E+00
212: Laurentian mixed forest (4)												
	1.23E-09	1.94E-10	0.00E+00	4.41E-11	6.96E-12	0.00E+00	7.93E-02	1.25E-02	0.00E+00	1.11E-02	1.74E-03	0.00E+00
M242: Cascade mixed forest–coniferous forest–alpine meadow (4)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.93E-02	1.25E-02	0.00E+00	1.11E-02	1.74E-03	0.00E+00
232: Outer coastal plain mixed forest (6)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-01	1.88E-02	0.00E+00	1.66E-02	2.62E-03	0.00E+00
131: Yukon intermontane plateaus taiga (6)												
	5.32E-06	8.39E-07	0.00E+00	1.91E-07	3.00E-08	0.00E+00	1.19E-01	1.88E-02	0.00E+00	1.66E-02	2.62E-03	0.00E+00
M262: California coastal range open woodland–shrub–coniferous forest–meadow (6)												
	6.75E-11	1.06E-11	0.00E+00	2.78E-12	4.39E-13	0.00E+00	1.19E-01	1.88E-02	0.00E+00	1.66E-02	2.62E-03	0.00E+00

Risks to Aquatic Species from Accidental Spills

	Estimated Risk Quotient					
	Small Stream			***Large Stream***		
Spill Type	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
Bulk Powdered Retardant	NA	NA	NA	NA	NA	NA
Wet Retardant Concentrate	**6.86E+01**	**1.08E+01**	ND	**2.35E+00**	3.71E-01	ND
Tank-Mixed Retardant	**1.06E+01**	**1.30E+03**	ND	3.62E-01	5.70E-02	ND

Phos-Chek LC-95A-R (1051695-A)

Product Data

Concentrate form:	Liquid	
Mix ratio:	1	gal concentrate / 5.5 gal water
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation LC_{50} (mg/L):	346	(Rainbow trout, 96 hours)
Mixture application rate:	0.06	gal/ft^2

Estimated Risks to Terrestrial Species: Product

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	3.84E-03	3.08E-04	3.86E-02	8.36E-03	2.04E-03	1.94E-02	2.22E-02	8.75E-03
2	7.69E-03	6.17E-04	7.72E-02	1.67E-02	4.07E-03	3.88E-02	4.45E-02	1.75E-02
3	1.15E-02	9.25E-04	1.16E-01	2.51E-02	6.11E-03	5.82E-02	6.67E-02	2.62E-02
4	1.54E-02	1.23E-03	1.54E-01	3.34E-02	8.14E-03	7.76E-02	8.90E-02	3.50E-02
6	2.31E-02	1.85E-03	2.31E-01	5.01E-02	1.22E-02	1.16E-01	1.33E-01	5.25E-02

Estimated Risks to Terrestrial Species:
Additive Risk Based on Ingredients Screened into Analysis

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	6.05E-03	4.85E-04	6.07E-02	1.31E-02	3.20E-03	3.05E-02	3.50E-02	1.38E-02
2	1.21E-02	9.70E-04	1.21E-01	2.63E-02	6.40E-03	6.10E-02	7.00E-02	2.75E-02
3	1.81E-02	1.46E-03	1.82E-01	3.94E-02	9.60E-03	9.16E-02	1.05E-01	4.13E-02
4	2.42E-02	1.94E-03	2.43E-01	5.26E-02	1.28E-02	1.22E-01	1.40E-01	5.50E-02
6	3.63E-02	2.91E-03	3.64E-01	7.88E-02	1.92E-02	1.83E-01	2.10E-01	8.26E-02

Summary of Risks to Aquatic Species

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			***Large Stream***			***Small Stream***			***Large Stream***		
	Rainbow Trout	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	**Daphnia magna**	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
331: Great Plains-Palouse dry steppe (1)												
	1.36E-08	2.14E-09	0.00E+00	5.72E-10	9.03E-11	0.00E+00	1.96E-02	3.09E-03	0.00E+00	2.74E-03	4.31E-04	0.00E+00
M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow (2)												
	1.89E-08	2.98E-09	0.00E+00	6.73E-10	1.06E-10	0.00E+00	3.92E-02	6.19E-03	0.00E+00	5.47E-03	8.63E-04	0.00E+00
M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow (2)												
	9.89E-09	1.56E-09	0.00E+00	4.10E-10	6.46E-11	0.00E+00	3.92E-02	6.19E-03	0.00E+00	5.47E-03	8.63E-04	0.00E+00
M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow (2)												
	1.10E-07	1.73E-08	0.00E+00	4.67E-09	7.36E-10	0.00E+00	3.92E-02	6.19E-03	0.00E+00	5.47E-03	8.63E-04	0.00E+00
242: Pacific lowland mixed forest (2)												
	3.91E-08	6.17E-09	0.00E+00	1.70E-09	2.68E-10	0.00E+00	3.92E-02	6.19E-03	0.00E+00	5.47E-03	8.63E-04	0.00E+00
234: Lower Mississippi riverine forest (2)												
	4.30E-09	6.78E-10	0.00E+00	1.68E-10	2.64E-11	0.00E+00	3.92E-02	6.19E-03	0.00E+00	5.47E-03	8.63E-04	0.00E+00
M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow (2)												
	7.21E-10	1.14E-10	0.00E+00	2.58E-11	4.07E-12	0.00E+00	3.92E-02	6.19E-03	0.00E+00	5.47E-03	8.63E-04	0.00E+00

Summary of Risks to Aquatic Species (continued)

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
231: Southeastern mixed forest (2)	1.27E-08	2.00E-09	0.00E+00	5.51E-10	8.68E-11	0.00E+00	3.92E-02	6.19E-03	0.00E+00	5.47E-03	8.63E-04	0.00E+00
342: Intermountain semi-desert (3)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.89E-02	9.28E-03	0.00E+00	8.21E-03	1.29E-03	0.00E+00
315: Southwest plateau and plains dry steppe and shrub (3)	2.18E-06	3.43E-07	0.00E+00	9.41E-08	1.48E-08	0.00E+00	5.89E-02	9.28E-03	0.00E+00	8.21E-03	1.29E-03	0.00E+00
212: Laurentian mixed forest (4)	1.22E-09	1.92E-10	0.00E+00	4.37E-11	6.89E-12	0.00E+00	7.85E-02	1.24E-02	0.00E+00	1.09E-02	1.73E-03	0.00E+00
M242: Cascade mixed forest–coniferous forest–alpine meadow (4)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.85E-02	1.24E-02	0.00E+00	1.09E-02	1.73E-03	0.00E+00
232: Outer coastal plain mixed forest (6)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-01	1.86E-02	0.00E+00	1.64E-02	2.59E-03	0.00E+00
131: Yukon intermontane plateaus taiga (6)	5.26E-06	8.30E-07	0.00E+00	1.89E-07	2.97E-08	0.00E+00	1.18E-01	1.86E-02	0.00E+00	1.64E-02	2.59E-03	0.00E+00
M262: California coastal range open woodland–shrub–coniferous forest–meadow (6)	6.68E-11	1.05E-11	0.00E+00	2.75E-12	4.34E-13	0.00E+00	1.18E-01	1.86E-02	0.00E+00	1.64E-02	2.59E-03	0.00E+00

Risks to Aquatic Species from Accidental Spills

	Estimated Risk Quotient					
	Small Stream			***Large Stream***		
Spill Type	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
Bulk Powdered Retardant	NA	NA	NA	NA	NA	NA
Wet Retardant Concentrate	**6.79E+01**	**1.07E+01**	ND	**2.33E+00**	3.67E-01	ND
Tank-Mixed Retardant	**1.04E+01**	**1.28E+03**	ND	3.58E-01	5.65E-02	ND

Phos-Chek LC95A-Fx (0439-076B)

Product Data

Concentrate form:	Liquid	
Mix ratio:	1	gal concentrate / 5.5 gal water
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation LC_{50} (mg/L):	399	(Rainbow trout, 96 hours)
Mixture application rate:	0.06	gal/ft^2

Estimated Risks to Terrestrial Species: Product

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	3.85E-03	3.09E-04	3.87E-02	8.38E-03	2.04E-03	1.95E-02	2.23E-02	8.77E-03
2	7.71E-03	6.18E-04	7.74E-02	1.68E-02	4.08E-03	3.89E-02	4.46E-02	1.75E-02
3	1.16E-02	9.27E-04	1.16E-01	2.51E-02	6.12E-03	5.84E-02	6.69E-02	2.63E-02
4	1.54E-02	1.24E-03	1.55E-01	3.35E-02	8.16E-03	7.78E-02	8.92E-02	3.51E-02
6	2.31E-02	1.85E-03	2.32E-01	5.03E-02	1.22E-02	1.17E-01	1.34E-01	5.26E-02

Estimated Risks to Terrestrial Species:
Additive Risk Based on Ingredients Screened into Analysis

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	6.11E-03	4.90E-04	6.13E-02	1.31E-02	3.18E-03	3.08E-02	3.53E-02	1.39E-02
2	1.22E-02	9.80E-04	1.23E-01	2.62E-02	6.36E-03	6.17E-02	7.07E-02	2.78E-02
3	1.83E-02	1.47E-03	1.84E-01	3.93E-02	9.55E-03	9.25E-02	1.06E-01	4.17E-02
4	2.44E-02	1.96E-03	2.45E-01	5.23E-02	1.27E-02	1.23E-01	1.41E-01	5.56E-02
6	3.67E-02	2.94E-03	3.68E-01	7.85E-02	1.91E-02	1.85E-01	2.12E-01	8.34E-02

Summary of Risks to Aquatic Species

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	**Daphnia magna**	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
331: Great Plains-Palouse dry steppe (1)												
	3.20E-06	3.19E-06	0.00E+00	1.35E-07	1.34E-07	0.00E+00	2.90E-02	1.26E-02	0.00E+00	4.05E-03	1.75E-03	0.00E+00
M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow (2)												
	3.86E-06	3.85E-06	0.00E+00	1.37E-07	1.37E-07	0.00E+00	5.81E-02	2.51E-02	0.00E+00	8.10E-03	3.51E-03	0.00E+00
M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow (2)												
	1.74E-05	1.74E-05	0.00E+00	7.19E-07	7.19E-07	0.00E+00	5.81E-02	2.51E-02	0.00E+00	8.10E-03	3.51E-03	0.00E+00
M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow (2)												
	2.24E-04	2.24E-04	0.00E+00	9.54E-06	9.54E-06	0.00E+00	5.81E-02	2.51E-02	0.00E+00	8.10E-03	3.51E-03	0.00E+00
242: Pacific lowland mixed forest (2)												
	1.80E-04	1.80E-04	0.00E+00	7.79E-06	7.79E-06	0.00E+00	5.81E-02	2.51E-02	0.00E+00	8.10E-03	3.51E-03	0.00E+00
234: Lower Mississippi riverine forest (2)												
	1.80E-05	1.80E-05	0.00E+00	6.25E-07	6.25E-07	0.00E+00	5.81E-02	2.51E-02	0.00E+00	8.10E-03	3.51E-03	0.00E+00
M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow (2)												
	1.32E-04	1.32E-04	0.00E+00	4.71E-06	4.71E-06	0.00E+00	5.81E-02	2.51E-02	0.00E+00	8.10E-03	3.51E-03	0.00E+00

Summary of Risks to Aquatic Species (continued)

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
231: Southeastern mixed forest (2)												
	1.22E-08	1.92E-09	0.00E+00	5.29E-10	8.33E-11	0.00E+00	5.81E-02	2.51E-02	0.00E+00	8.10E-03	3.51E-03	0.00E+00
342: Intermountain semi-desert (3)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.71E-02	3.77E-02	0.00E+00	1.21E-02	5.26E-03	0.00E+00
315: Southwest plateau and plains dry steppe and shrub (3)												
	5.74E-05	5.56E-05	0.00E+00	2.00E-06	1.92E-06	0.00E+00	8.71E-02	3.77E-02	0.00E+00	1.21E-02	5.26E-03	0.00E+00
212: Laurentian mixed forest (4)												
	2.26E-04	2.26E-04	0.00E+00	8.13E-06	8.13E-06	0.00E+00	1.16E-01	5.03E-02	0.00E+00	1.62E-02	7.01E-03	0.00E+00
M242: Cascade mixed forest–coniferous forest–alpine meadow (4)												
	4.34E-04	4.34E-04	0.00E+00	1.52E-05	1.52E-05	0.00E+00	1.16E-01	5.03E-02	0.00E+00	1.62E-02	7.01E-03	0.00E+00
232: Outer coastal plain mixed forest (6)												
	1.56E-05	1.56E-05	0.00E+00	5.41E-07	5.41E-07	0.00E+00	1.74E-01	7.54E-02	0.00E+00	2.43E-02	1.05E-02	0.00E+00
131: Yukon intermontane plateaus taiga (6)												
	8.62E-03	8.62E-03	0.00E+00	3.09E-04	3.09E-04	0.00E+00	1.74E-01	7.54E-02	0.00E+00	2.43E-02	1.05E-02	0.00E+00
M262: California coastal range open woodland–shrub–coniferous forest–meadow (6)												
	1.74E-05	1.74E-05	0.00E+00	7.17E-07	7.17E-07	0.00E+00	1.74E-01	7.54E-02	0.00E+00	2.43E-02	1.05E-02	0.00E+00

Risks to Aquatic Species from Accidental Spills

	Estimated Risk Quotient					
	Small Stream			*Large Stream*		
Spill Type	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
Bulk Powdered Retardant	NA	NA	NA	NA	NA	NA
Wet Retardant Concentrate	**1.00E+02**	**4.35E+01**	ND	**3.44E+00**	**1.49E+00**	ND
Tank-Mixed Retardant	**1.55E+01**	**6.69E+00**	ND	**5.30E-01**	2.29E-01	ND

Phos-Chek LC-95A-F (0381-045C)

Product Data

Concentrate form:	Liquid	
Mix ratio:	1	gal concentrate / 5.5 gal water
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation LC_{50} (mg/L):	225	(Rainbow trout, 96 hours)
Mixture application rate:	0.06	gal/ft^2

Estimated Risks to Terrestrial Species: Product

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	3.88E-03	3.11E-04	3.89E-02	8.44E-03	2.05E-03	1.96E-02	2.24E-02	8.83E-03
2	7.76E-03	6.23E-04	7.79E-02	1.69E-02	4.11E-03	3.92E-02	4.49E-02	1.77E-02
3	1.16E-02	9.34E-04	1.17E-01	2.53E-02	6.16E-03	5.88E-02	6.73E-02	2.65E-02
4	1.55E-02	1.25E-03	1.56E-01	3.37E-02	8.22E-03	7.84E-02	8.98E-02	3.53E-02
6	2.33E-02	1.87E-03	2.34E-01	5.06E-02	1.23E-02	1.18E-01	1.35E-01	5.30E-02

Estimated Risks to Terrestrial Species: Additive Risk Based on Ingredients Screened into Analysis

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	6.10E-03	4.89E-04	6.12E-02	1.33E-02	3.23E-03	3.08E-02	3.53E-02	1.39E-02
2	1.22E-02	9.78E-04	1.22E-01	2.65E-02	6.46E-03	6.16E-02	7.06E-02	2.78E-02
3	1.83E-02	1.47E-03	1.84E-01	3.98E-02	9.68E-03	9.23E-02	1.06E-01	4.16E-02
4	2.44E-02	1.96E-03	2.45E-01	5.30E-02	1.29E-02	1.23E-01	1.41E-01	5.55E-02
6	3.66E-02	2.94E-03	3.67E-01	7.95E-02	1.94E-02	1.85E-01	2.12E-01	8.33E-02

Summary of Risks to Aquatic Species

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
331: Great Plains-Palouse dry steppe (1)												
	1.38E-08	2.17E-09	0.00E+00	5.79E-10	9.14E-11	0.00E+00	1.99E-02	3.13E-03	0.00E+00	2.77E-03	4.37E-04	0.00E+00
M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow (2)												
	1.91E-08	3.01E-09	0.00E+00	6.79E-10	1.07E-10	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00
M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow (2)												
	9.94E-09	1.57E-09	0.00E+00	4.12E-10	6.49E-11	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00
M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow (2)												
	1.11E-07	1.74E-08	0.00E+00	4.71E-09	7.42E-10	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00
242: Pacific lowland mixed forest (2)												
	3.95E-08	6.23E-09	0.00E+00	1.71E-09	2.70E-10	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00
234: Lower Mississippi riverine forest (2)												
	4.34E-09	6.85E-10	0.00E+00	1.69E-10	2.67E-11	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00
M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow (2)												
	7.15E-10	1.13E-10	0.00E+00	2.56E-11	4.04E-12	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00

Summary of Risks to Aquatic Species (continued)

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
231: Southeastern mixed forest (2)												
	1.28E-08	2.03E-09	0.00E+00	5.56E-10	8.77E-11	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00
342: Intermountain semi-desert (3)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.96E-02	9.39E-03	0.00E+00	8.31E-03	1.31E-03	0.00E+00
315: Southwest plateau and plains dry steppe and shrub (3)												
	2.19E-06	3.46E-07	0.00E+00	9.49E-08	1.50E-08	0.00E+00	5.96E-02	9.39E-03	0.00E+00	8.31E-03	1.31E-03	0.00E+00
212: Laurentian mixed forest (4)												
	1.23E-09	1.94E-10	0.00E+00	4.41E-11	6.96E-12	0.00E+00	7.94E-02	1.25E-02	0.00E+00	1.11E-02	1.75E-03	0.00E+00
M242: Cascade mixed forest–coniferous forest–alpine meadow (4)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.94E-02	1.25E-02	0.00E+00	1.11E-02	1.75E-03	0.00E+00
232: Outer coastal plain mixed forest (6)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-01	1.88E-02	0.00E+00	1.66E-02	2.62E-03	0.00E+00
131: Yukon intermontane plateaus taiga (6)												
	5.31E-06	8.37E-07	0.00E+00	1.90E-07	3.00E-08	0.00E+00	1.19E-01	1.88E-02	0.00E+00	1.66E-02	2.62E-03	0.00E+00
M262: California coastal range open woodland–shrub–coniferous forest–meadow (6)												
	6.74E-11	1.06E-11	0.00E+00	2.78E-12	4.38E-13	0.00E+00	1.19E-01	1.88E-02	0.00E+00	1.66E-02	2.62E-03	0.00E+00

Risks to Aquatic Species from Accidental Spills

	Estimated Risk Quotient					
	Small Stream			***Large Stream***		
Spill Type	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
Bulk Powdered Retardant	NA	NA	NA	NA	NA	NA
Wet Retardant Concentrate	**6.87E+01**	**1.08E+01**	ND	**2.36E+00**	3.71E-01	ND
Tank-Mixed Retardant	**1.06E+01**	**1.30E+03**	ND	3.62E-01	5.71E-02	ND

Phos-Chek LC-95A-F (0381-045D)

Product Data

Concentrate form:	Liquid	
Mix ratio:	1	gal concentrate / 5.5 gal water
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation LC_{50} (mg/L):	225	(Rainbow trout, 96 hours)
Mixture application rate:	0.06	gal/ft^2

Estimated Risks to Terrestrial Species: Product

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	3.88E-03	3.11E-04	3.89E-02	8.44E-03	2.05E-03	1.96E-02	2.24E-02	8.83E-03
2	7.76E-03	6.23E-04	7.79E-02	1.69E-02	4.11E-03	3.92E-02	4.49E-02	1.77E-02
3	1.16E-02	9.34E-04	1.17E-01	2.53E-02	6.16E-03	5.88E-02	6.73E-02	2.65E-02
4	1.55E-02	1.25E-03	1.56E-01	3.37E-02	8.22E-03	7.84E-02	8.98E-02	3.53E-02
6	2.33E-02	1.87E-03	2.34E-01	5.06E-02	1.23E-02	1.18E-01	1.35E-01	5.30E-02

Estimated Risks to Terrestrial Species: Additive Risk Based on Ingredients Screened into Analysis

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	6.10E-03	4.89E-04	6.12E-02	1.33E-02	3.23E-03	3.08E-02	3.53E-02	1.39E-02
2	1.22E-02	9.78E-04	1.22E-01	2.65E-02	6.46E-03	6.16E-02	7.06E-02	2.78E-02
3	1.83E-02	1.47E-03	1.84E-01	3.98E-02	9.68E-03	9.23E-02	1.06E-01	4.16E-02
4	2.44E-02	1.96E-03	2.45E-01	5.30E-02	1.29E-02	1.23E-01	1.41E-01	5.55E-02
6	3.66E-02	2.94E-03	3.67E-01	7.95E-02	1.94E-02	1.85E-01	2.12E-01	8.33E-02

Summary of Risks to Aquatic Species

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						**Accidental Application to Stream (Based on Ingredient Toxicity)**					
	Small Stream			***Large Stream***			***Small Stream***			***Large Stream***		
	Rainbow Trout	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	**Daphnia magna**	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
331: Great Plains-Palouse dry steppe (1)												
	1.38E-08	2.17E-09	0.00E+00	5.79E-10	9.14E-11	0.00E+00	1.99E-02	3.13E-03	0.00E+00	2.77E-03	4.37E-04	0.00E+00
M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow (2)												
	1.91E-08	3.01E-09	0.00E+00	6.79E-10	1.07E-10	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00
M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow (2)												
	9.94E-09	1.57E-09	0.00E+00	4.12E-10	6.49E-11	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00
M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow (2)												
	1.11E-07	1.74E-08	0.00E+00	4.71E-09	7.42E-10	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00
242: Pacific lowland mixed forest (2)												
	3.95E-08	6.23E-09	0.00E+00	1.71E-09	2.70E-10	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00
234: Lower Mississippi riverine forest (2)												
	4.34E-09	6.85E-10	0.00E+00	1.69E-10	2.67E-11	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00
M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow (2)												
	7.15E-10	1.13E-10	0.00E+00	2.56E-11	4.04E-12	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00

Summary of Risks to Aquatic Species (continued)

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
231: Southeastern mixed forest (2)												
	1.28E-08	2.03E-09	0.00E+00	5.56E-10	8.77E-11	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.54E-03	8.73E-04	0.00E+00
342: Intermountain semi-desert (3)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.96E-02	9.39E-03	0.00E+00	8.31E-03	1.31E-03	0.00E+00
315: Southwest plateau and plains dry steppe and shrub (3)												
	2.19E-06	3.46E-07	0.00E+00	9.49E-08	1.50E-08	0.00E+00	5.96E-02	9.39E-03	0.00E+00	8.31E-03	1.31E-03	0.00E+00
212: Laurentian mixed forest (4)												
	1.23E-09	1.94E-10	0.00E+00	4.41E-11	6.96E-12	0.00E+00	7.94E-02	1.25E-02	0.00E+00	1.11E-02	1.75E-03	0.00E+00
M242: Cascade mixed forest–coniferous forest–alpine meadow (4)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.94E-02	1.25E-02	0.00E+00	1.11E-02	1.75E-03	0.00E+00
232: Outer coastal plain mixed forest (6)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-01	1.88E-02	0.00E+00	1.66E-02	2.62E-03	0.00E+00
131: Yukon intermontane plateaus taiga (6)												
	5.31E-06	8.37E-07	0.00E+00	1.90E-07	3.00E-08	0.00E+00	1.19E-01	1.88E-02	0.00E+00	1.66E-02	2.62E-03	0.00E+00
M262: California coastal range open woodland–shrub–coniferous forest–meadow (6)												
	6.74E-11	1.06E-11	0.00E+00	2.78E-12	4.38E-13	0.00E+00	1.19E-01	1.88E-02	0.00E+00	1.66E-02	2.62E-03	0.00E+00

Risks to Aquatic Species from Accidental Spills

Spill Type	Estimated Risk Quotient					
	Small Stream			***Large Stream***		
	Rainbow Trout	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
Bulk Powdered Retardant	NA	NA	NA	NA	NA	NA
Wet Retardant Concentrate	**6.87E+01**	**1.08E+01**	ND	**2.36E+00**	3.71E-01	ND
Tank-Mixed Retardant	**1.06E+01**	**1.30E+03**	ND	3.62E-01	5.71E-02	ND

Phos-Chek LC-95W (0381-090B)

Product Data

Concentrate form:	Liquid	
Mix ratio:	1	gal concentrate / 5.5. gal water
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation LC_{50} (mg/L):	465	(Rainbow trout, 96 hours)
Mixture application rate:	0.06	gal/ft^2

Estimated Risks to Terrestrial Species: Product

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	3.85E-03	3.09E-04	3.87E-02	8.38E-03	2.04E-03	1.95E-02	2.23E-02	8.77E-03
2	7.71E-03	6.18E-04	7.74E-02	1.68E-02	4.08E-03	3.89E-02	4.46E-02	1.75E-02
3	1.16E-02	9.27E-04	1.16E-01	2.51E-02	6.12E-03	5.84E-02	6.69E-02	2.63E-02
4	1.54E-02	1.24E-03	1.55E-01	3.35E-02	8.16E-03	7.78E-02	8.92E-02	3.51E-02
6	2.31E-02	1.85E-03	2.32E-01	5.03E-02	1.22E-02	1.17E-01	1.34E-01	5.26E-02

Estimated Risks to Terrestrial Species: Additive Risk Based on Ingredients Screened into Analysis

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	6.11E-03	4.90E-04	6.13E-02	1.33E-02	3.23E-03	3.08E-02	3.53E-02	1.39E-02
2	1.22E-02	9.79E-04	1.23E-01	2.65E-02	6.46E-03	6.16E-02	7.06E-02	2.78E-02
3	1.83E-02	1.47E-03	1.84E-01	3.98E-02	9.70E-03	9.24E-02	1.06E-01	4.17E-02
4	2.44E-02	1.96E-03	2.45E-01	5.31E-02	1.29E-02	1.23E-01	1.41E-01	5.56E-02
6	3.66E-02	2.94E-03	3.68E-01	7.96E-02	1.94E-02	1.85E-01	2.12E-01	8.34E-02

Summary of Risks to Aquatic Species

	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
Eco-region (GPC)	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
331: Great Plains-Palouse dry steppe (1)												
	1.37E-08	2.15E-09	0.00E+00	5.75E-10	9.07E-11	0.00E+00	1.98E-02	3.13E-03	0.00E+00	2.77E-03	4.36E-04	0.00E+00
M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow (2)												
	1.91E-08	3.01E-09	0.00E+00	6.79E-10	1.07E-10	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.53E-03	8.73E-04	0.00E+00
M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow (2)												
	9.94E-09	1.57E-09	0.00E+00	4.12E-10	6.49E-11	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.53E-03	8.73E-04	0.00E+00
M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow (2)												
	1.11E-07	1.75E-08	0.00E+00	4.71E-09	7.43E-10	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.53E-03	8.73E-04	0.00E+00
242: Pacific lowland mixed forest (2)												
	3.95E-08	6.23E-09	0.00E+00	1.71E-09	2.70E-10	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.53E-03	8.73E-04	0.00E+00
234: Lower Mississippi riverine forest (2)												
	4.34E-09	6.85E-10	0.00E+00	1.69E-10	2.67E-11	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.53E-03	8.73E-04	0.00E+00
M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow (2)												
	7.28E-10	1.15E-10	0.00E+00	2.61E-11	4.11E-12	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.53E-03	8.73E-04	0.00E+00

Summary of Risks to Aquatic Species (continued)

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
231: Southeastern mixed forest (2)												
	1.28E-08	2.03E-09	0.00E+00	5.56E-10	8.77E-11	0.00E+00	3.97E-02	6.26E-03	0.00E+00	5.53E-03	8.73E-04	0.00E+00
342: Intermountain semi-desert (3)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.95E-02	9.39E-03	0.00E+00	8.30E-03	1.31E-03	0.00E+00
315: Southwest plateau and plains dry steppe and shrub (3)												
	2.20E-06	3.46E-07	0.00E+00	9.50E-08	1.50E-08	0.00E+00	5.95E-02	9.39E-03	0.00E+00	8.30E-03	1.31E-03	0.00E+00
212: Laurentian mixed forest (4)												
	1.23E-09	1.94E-10	0.00E+00	4.41E-11	6.96E-12	0.00E+00	7.94E-02	1.25E-02	0.00E+00	1.11E-02	1.75E-03	0.00E+00
M242: Cascade mixed forest–coniferous forest–alpine meadow (4)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.94E-02	1.25E-02	0.00E+00	1.11E-02	1.75E-03	0.00E+00
232: Outer coastal plain mixed forest (6)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-01	1.88E-02	0.00E+00	1.66E-02	2.62E-03	0.00E+00
131: Yukon intermontane plateaus taiga (6)												
	5.32E-06	8.38E-07	0.00E+00	1.90E-07	3.00E-08	0.00E+00	1.19E-01	1.88E-02	0.00E+00	1.66E-02	2.62E-03	0.00E+00
M262: California coastal range open woodland–shrub–coniferous forest–meadow (6)												
	6.75E-11	1.06E-11	0.00E+00	2.78E-12	4.39E-13	0.00E+00	1.19E-01	1.88E-02	0.00E+00	1.66E-02	2.62E-03	0.00E+00

Risks to Aquatic Species from Accidental Spills

	Estimated Risk Quotient					
	Small Stream			***Large Stream***		
Spill Type	**Rainbow Trout**	***Daphnia magna***	**Tadpole**	**Rainbow Trout**	***Daphnia magna***	**Tadpole**
Bulk Powdered Retardant	NA	NA	NA	NA	NA	NA
Wet Retardant Concentrate	**6.87E+01**	**1.08E+01**	ND	**2.35E+00**	3.71E-01	ND
Tank-Mixed Retardant	**1.06E+01**	**1.30E+03**	ND	3.62E-01	5.71E-02	ND

Appendix B

Ecological Risk Assessments for Conditionally or Interim Qualified Retardant Products

June 2020

Product	Formulation ID Number(s) Evaluated in Risk Assessment	
Phos-Chek LCE20-Fx	0502-050A	

Scientific notation: Some of the risk tables in this section use scientific notation, since many of the values are very small. For example, the notation 3.63E-001 represents 3.63 x 10^{-1}, or 0.363. Similarly, 4.65E-009 represents 4.65 x 10^{-9}, or 0.00000000465.

Shaded cells in these tables indicate the exposures that are predicted to present a risk to sensitive species.

Shaded and boldfaced entries indicate a risk to both non-sensitive and sensitive species.

NA = not applicable.
ND = no data.

Phos-Chek LCE20-Fx (0502-050A)

Product Data

Concentrate form:	Liquid	
Mix ratio:	1	gal concentrate / 5.2 gal water
Formulation Oral LD_{50}:	5,000	mg/kg
Formulation LC_{50} (mg/L):	983.1	(Rainbow trout, 96 hours)
Mixture application rate:	0.06	gal/ft^2

Estimated Risks to Terrestrial Species: Product

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	3.75E-03	2.95E-04	3.76E-02	8.15E-03	1.98E-03	1.83E-02	2.17E-02	8.53E-03
2	7.50E-03	5.89E-04	7.52E-02	1.63E-02	3.97E-03	3.67E-02	4.34E-02	1.71E-02
3	1.12E-02	8.84E-04	1.13E-01	2.44E-02	5.95E-03	5.50E-02	6.51E-02	2.56E-02
4	1.50E-02	1.18E-03	1.50E-01	3.26E-02	7.94E-03	7.34E-02	8.67E-02	3.41E-02
6	2.25E-02	1.77E-03	2.26E-01	4.89E-02	1.19E-02	1.10E-01	1.30E-01	5.12E-02

Estimated Risks to Terrestrial Species: Additive Risk Based on Ingredients Screened into Analysis

Application Rate (GPC)	Risk Quotient							
	Deer	Coyote	Deer Mouse	Rabbit	Cow	Am Kestrel	RW Blackbird	BW Quail
1	1.86E-03	1.46E-04	1.87E-02	4.04E-03	9.85E-04	9.11E-03	1.08E-02	4.24E-03
2	3.72E-03	2.93E-04	3.73E-02	8.09E-03	1.97E-03	1.82E-02	2.15E-02	8.47E-03
3	5.58E-03	4.39E-04	5.60E-02	1.21E-02	2.96E-03	2.73E-02	3.23E-02	1.27E-02
4	7.44E-03	5.85E-04	7.47E-02	1.62E-02	3.94E-03	3.64E-02	4.31E-02	1.69E-02
6	1.12E-02	8.78E-04	1.12E-01	2.43E-02	5.91E-03	5.46E-02	6.46E-02	2.54E-02

Summary of Risks to Aquatic Species

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
331: Great Plains-Palouse dry steppe (1)												
	6.58E-05	4.49E-04	0.00E+00	2.77E-06	1.89E-05	0.00E+00	2.22E-02	7.06E-02	0.00E+00	3.17E-03	1.01E-02	0.00E+00
M313: Arizona-New Mexico mountains–semidesert–open woodland–coniferous forest–alpine meadow (2)												
	2.94E-04	1.99E-03	0.00E+00	1.05E-05	7.10E-05	0.00E+00	4.43E-02	1.41E-01	0.00E+00	6.33E-03	2.02E-02	0.00E+00
M331: Southern Rocky Mountain steppe–open woodland–coniferous forest–alpine meadow (2)												
	1.88E-04	1.29E-03	0.00E+00	7.80E-06	5.34E-05	0.00E+00	4.43E-02	1.41E-01	0.00E+00	6.33E-03	2.02E-02	0.00E+00
M332: Middle Rocky Mountain steppe–coniferous forest–alpine meadow (2)												
	1.52E-04	1.04E-03	0.00E+00	6.49E-06	4.41E-05	0.00E+00	4.43E-02	1.41E-01	0.00E+00	6.33E-03	2.02E-02	0.00E+00
242: Pacific lowland mixed forest (2)												
	8.93E-04	6.08E-03	0.00E+00	3.09E-05	2.11E-04	0.00E+00	4.43E-02	1.41E-01	0.00E+00	6.33E-03	2.02E-02	0.00E+00
234: Lower Mississippi riverine forest (2)												
	1.31E-03	8.94E-03	0.00E+00	4.53E-05	3.10E-04	0.00E+00	4.43E-02	1.41E-01	0.00E+00	6.33E-03	2.02E-02	0.00E+00
M212: Adirondack-New England mixed forest–coniferous forest–alpine meadow (2)												
	4.63E-04	3.17E-03	0.00E+00	1.66E-05	1.14E-04	0.00E+00	4.43E-02	1.41E-01	0.00E+00	6.33E-03	2.02E-02	0.00E+00

Summary of Risks to Aquatic Species (continued)

Eco-region (GPC)	Estimated Risk Quotient											
	Runoff						Accidental Application to Stream (Based on Ingredient Toxicity)					
	Small Stream			*Large Stream*			*Small Stream*			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	Daphnia magna	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
231: Southeastern mixed forest (2)												
	6.17E-05	2.81E-04	0.00E+00	2.13E-06	9.71E-06	0.00E+00	4.43E-02	1.41E-01	0.00E+00	6.33E-03	2.02E-02	0.00E+00
342: Intermountain semi-desert (3)												
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.65E-02	2.12E-01	0.00E+00	9.50E-03	3.03E-02	0.00E+00
315: Southwest plateau and plains dry steppe and shrub (3)												
	3.82E-03	2.61E-02	0.00E+00	1.32E-04	8.99E-04	0.00E+00	6.65E-02	2.12E-01	0.00E+00	9.50E-03	3.03E-02	0.00E+00
212: Laurentian mixed forest (4)												
	8.53E-04	5.83E-03	0.00E+00	3.06E-05	2.09E-04	0.00E+00	8.86E-02	2.82E-01	0.00E+00	1.27E-02	4.03E-02	0.00E+00
M242: Cascade mixed forest–coniferous forest–alpine meadow (4)												
	1.92E-03	1.31E-02	0.00E+00	6.71E-05	4.59E-04	0.00E+00	8.86E-02	2.82E-01	0.00E+00	1.27E-02	4.03E-02	0.00E+00
232: Outer coastal plain mixed forest (6)												
	3.12E-03	2.13E-02	0.00E+00	1.08E-04	7.36E-04	0.00E+00	1.33E-01	4.24E-01	0.00E+00	1.90E-02	6.05E-02	0.00E+00
131: Yukon intermontane plateaus taiga (6)												
	2.99E-03	1.99E-02	0.00E+00	1.07E-04	7.12E-04	0.00E+00	1.33E-01	4.24E-01	0.00E+00	1.90E-02	6.05E-02	0.00E+00
M262: California coastal range open woodland–shrub–coniferous forest–meadow (6)												
	3.11E-04	2.13E-03	0.00E+00	1.28E-05	8.76E-05	0.00E+00	1.33E-01	4.24E-01	0.00E+00	1.90E-02	6.05E-02	0.00E+00

Risks to Aquatic Species from Accidental Application to Stream (based on product toxicity)

Application Rate (gpc)	Estimated Risk Quotient					
	Small Stream			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
1	5.48E-03	ND	ND	7.82E-04	ND	ND
2	1.10E-02	ND	ND	1.56E-03	ND	ND
3	1.64E-02	ND	ND	2.35E-03	ND	ND
4	2.19E-02	ND	ND	3.13E-03	ND	ND
6	3.29E-02	ND	ND	4.69E-03	ND	ND

Risks to Aquatic Species from Accidental Spills (based on ingredient toxicity)

Spill Type	Estimated Risk Quotient					
	Small Stream			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
Bulk Powdered Retardant	NA	NA	NA	NA	NA	NA
Wet Retardant Concentrate	**3.39E+01**	**1.08E+02**	ND	**1.16E+00**	**3.71E+00**	ND
Tank-Mixed Retardant	**5.47E+00**	**1.74E+01**	ND	1.88E-01	**5.98E-01**	ND

Risks to Aquatic Species from Accidental Spills (based on product toxicity)

Spill Type	Estimated Risk Quotient					
	Small Stream			*Large Stream*		
	Rainbow Trout	*Daphnia magna*	Tadpole	Rainbow Trout	*Daphnia magna*	Tadpole
Bulk Powdered Retardant	NA	NA	NA	NA	NA	NA
Wet Retardant Concentrate	**8.38E+00**	ND	ND	2.87E-01	ND	ND
Tank-Mixed Retardant	**1.35E+00**	ND	ND	4.64E-02	ND	ND