Human Health Risk Assessment

Final

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EXECUTIVE SUMMARY

The United States Department of the Interior (USDOI) Bureau of Land Management (BLM) administers about 247.9 million acres in 17 western states in the continental United States (U.S.) and Alaska. One of the BLM's highest priorities is to promote ecosystem health, and one of the greatest obstacles to achieving this goal is the rapid expansion of invasive plants (including noxious weeds and other plants not native to an area) across public lands. These invasive plants can dominate and often cause permanent damage to natural plant communities. If not eradicated or controlled, invasive plants will jeopardize the health of public lands and the activities that occur on them. Herbicides are one method employed by the BLM to control these plants.

In 2007, the BLM published the *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic Environmental Impact Statement* (17-States PEIS). The Record of Decision (ROD) for the 17-States PEIS allowed the BLM to use 18 herbicide active ingredients available for a full range of vegetation treatments in 17 western states. In the ROD, the BLM also identified a protocol for identifying, evaluating, and using the new herbicide active ingredients. Under the protocol, the BLM would not be allowed to use a new herbicide active ingredient until 1) the agency assessed the hazards and risks from using the new herbicide active ingredient, and 2) prepared an Environmental Impact Statement (EIS) under the National Environmental Policy Act to assess the impacts of using the new herbicide active ingredient on the natural, cultural, and social environment. A final decision on whether a new active ingredient was approved would be recorded in the EIS ROD.

This Human Health Risk Assessment (HHRA) evaluates the risk to humans from two herbicide active ingredients that the BLM is using, and three that it is proposing for use, on public lands:

- Aminopyralid (proposed for use)
- Clopyralid (currently in use)
- 2,4-Dichlorophenoxyacetic acid (2,4-D; currently in use)
- Fluroxypyr (proposed for use)
- Rimsulfuron (proposed for use)

The BLM is preparing a *Draft Vegetation Treatments Using Aminopyralid, Fluroxypyr, and Rimsulfuron on Bureau of Land Management Lands in 17 Western States Programmatic Environmental Impact Statement* to evaluate the risks to the public and the environment from the proposed use of aminopyralid, fluroxypyr, and rimsulfuron, as required by the protocol.

In the 17-States PEIS, the BLM relied on human health and ecological risk assessments prepared by the U.S. Department of Agriculture Forest Service to evaluate the risks from the use of 2.4-D and clopyralid. As part of its ongoing program to evaluate the risks from using herbicides, the BLM conducted is own risk assessments for 2,4-D and clopyralid to better assess risks from using these two herbicides under BLM application methods and usage rates and in areas administered by the BLM.

The HHRA follows the four-step risk assessment paradigm identified by the National Academy of Sciences:

- Hazard Identification - review information on the herbicide active ingredients characteristics and usage, and toxicity profiles to determine its level of toxicity for various criteria (oral, inhalation, and dermal acute toxicity, eye irritation, skin irritation, and dermal sensitization).
- Dose-response Assessment - evaluate non-carcinogenic effects (the active ingredients listed above are not considered potential carcinogens) depending on whether the exposure is dietary or non-dietary.

Dietary exposures are expressed as a percent of Population Adjusted Dose (%PAD). Non-dietary exposures are evaluated by dividing a No Observable Adverse Effects Level (NOAEL) by the site-specific intake to calculate a Margin of Error (MOE).

- Exposure Assessment - identify receptors and exposure scenarios and quantify exposures.

- Risk Characterization - provide quantitative risk estimates for each active ingredient for the various receptors and exposure scenarios. The Aggregate Risk Index (ARI) approach combines risks calculated using the %PAD and MOE methods. ARI values greater than 1 do not exceed the U.S. Environmental Protection Agency (USEPA) level of concern (in other words [i.e.], risk increases as ARI decreases) and indicate that adverse health effects are not expected.

Hazard Identification Results

The USEPA defines each toxicity endpoint with one of four toxicity categories (I through IV), with higher numbered categories representing lower acute toxicity. For most of the toxicity criteria, the herbicide active ingredients are in toxicity categories III and IV. Aminopyralid and 2,4-D are in category I for eye irritation, and fluroxypyr is in category II for acute inhalation toxicity. None of the herbicide active ingredients are designated as potential carcinogens by the USEPA.

Exposure Assessment Results

For use of herbicide active ingredients in the BLM's vegetation treatment program, it is assumed that occupational receptors may be incidentally exposed to the active ingredients through dermal contact and inhalation exposure routes. In addition, occupational receptors could be exposed to active ingredients as the result of an accidental spill of the active ingredient on the skin.

Members of the public (for example [e.g.], hikers, hunters, berry pickers, swimmers, anglers, nearby residents, and Native Americans using natural resources on public lands) may be incidentally exposed to herbicide active ingredients under a range of potential exposure scenarios. This HHRA assumes that these receptors could be exposed through one or more of the following exposure pathways:

- Dermal contact with spray
- Dermal contact with foliage
- Dermal contact with water while swimming
- Ingestion of drinking water or incidental ingestion of water while swimming
- Ingestion of berries
- Ingestion of fish

Although all public receptor exposures to herbicide active ingredients used on public lands are considered to be accidental, public receptor exposures are evaluated under two scenarios. Routine-use exposures are assumed to occur when public receptors come into contact with environmental media that have been impacted by spray drift. Accidental exposures are assumed to occur when public receptors come into contact with environmental media that have been subject to direct spray or spills.

Exposures to public receptors for the various exposure scenarios were quantified using computer models that estimate deposition of herbicide active ingredient drift, and active ingredient concentrations resulting from runoff (AgDRIFT®

and Groundwater Loading Effects of Agricultural Management Systems [GLEAMS]). Scenarios of accidental spills into a pond assumed that the entire contents of a truck or helicopter would spill into the pond.

Risk Characterization Results

The results of the HHRA show that aminopyralid, clopyralid, fluroxypyr, and rimsulfuron do not pose unacceptable risks for any of the occupational routine-use or public accidental exposure scenarios evaluated. Potentially unacceptable risks were identified for 2,4-D for a variety of uses and public and occupational routine-use and accidental exposures scenarios, and for rimsulfuron under the occupational accidental spill of solution to skin scenario. The majority of BLM's use of 2,4-D in terrestrial environments is for treatment of annual and perennial (non-woody) species. Under routine-use scenarios at the typical application rate of 1 pound of acid equivalent per acre (1 lb a.e./acre), no exceedances of USEPA's level of concern were identified for occupational or public receptors, indicating that adverse health effects are not expected under the routine-use scenario and an application rate of 1 lb a.e/acre.

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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

2,4-D	-	2,4-Dichlorophenoxyacetic acid
a.e.	-	Acid equivalent
a.i.	-	Active ingredient
AGDISP	-	Agricultural Dispersal Model
AR	-	Application Rate
ARI	-	Aggregate Risk Index
AT	-	Acres Treated per hour
ATV	-	All-Terrain Vehicle
BCF	-	Bioconcentration Factor
BLM	-	Bureau of Land Management
BR	-	Berry Residue
BW	-	Body Weight
C	-	Concentration
CBI	-	Confidential Business Information
CF	-	Conversion Factor
cm/hr	-	Centimeters per hour
cm^2	-	Square centimeters
CREAMS	-	Chemical Runoff Erosion Assessment Management System
Cs	-	Concentration of active ingredient in concentrate
DAF	-	Dermal Absorption Factor
DFR	-	Dislodgeable Foliar Residue
DR	-	Deposition Rate
di	-	Dermal intermediate-term
dl	-	Dermal long-term
ds	-	Dermal short-term
EDSP	-	Endocrine Disruptor Screening Program
EF	-	Exposure Factor
EFH	-	Exposure Factors Handbook
e.g.	-	For example
EIS	-	Environmental Impact Statement
EPC	-	Exposure Point Concentration
ET	-	Exposure Time
F	-	Fraction
FQPA	-	Food Quality Protection Act
g/day	-	Grams per day
g/kg-day	-	Grams per kilogram per day
GLEAMS	-	Groundwater Loading Effects of Agricultural Management Systems
H	-	Hours per day
HED	-	Health Effects Division
HHRA	-	Human Health Risk Assessment
HSDB	-	Hazardous Substances Data Bank
IAF	-	Inhalation Absorption Factor
i.e.	-	that is
ii	-	Inhalation – intermediate-term
il	-	Inhalation – long-term
IR	-	Ingestion Rate
is	-	Inhalation – short-term
kg	-	Kilograms
Kp	-	Dermal Permeability Constant
L	-	Liters
lb	-	Pound

LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS (Cont.)

LD_{50}	-	Median Lethal Dose to 50% of the test population
LOAEL	-	Lowest Observable Adverse Effect Level
m	-	meter
m^3	-	Cubic meter
mg/kg	-	Milligrams per kilogram
mg/kg-day	-	Milligrams per kilogram of body weight per day
mg/L	-	Milligrams per Liter
mg/lb	-	Milligrams per pound
MHE	-	Methylheptyl Ester
mL	-	Milliliters
MOE	-	Margin of Exposure
MRID	-	Master Record Identification
NAS	-	National Academy of Sciences
NEPA	-	National Environmental Policy Act
NOAEL	-	No Observable Adverse Effect Level
OEHHA	-	Office of Environmental Health Hazard Assessment
OPP	-	Office of Pesticide Programs
os	-	Oral short-term
PAD	-	Population Adjusted Dose
PEIS	-	Programmatic Environmental Impact Statement
PHED	-	Pesticide Handlers Exposure Database
PPE	-	Personal Protective Equipment
ppm	-	Parts per million
RED	-	Re-registration Eligibility Decision
RfD	-	Reference Dose
ROD	-	Record of Decision
S	-	Spill amount
SA	-	Surface Area
SAR	-	Surface Area Ratio
SDTF	-	Spray Drift Task Force
SERA	-	Syracuse Environmental Research Associates, Inc.
SF	-	Safety Factor
SOP	-	Standard Operating Procedure
Tc	-	Transfer coefficient, dermal
TIPA	-	Triisopropanol-ammonium
TM	-	Target MOE
U.S.	-	United States of America
UE	-	Unit Exposure
UF	-	Uncertainty Factor
USDOI	-	United States Department of the Interior
USEPA	-	United States Environmental Protection Agency
USLE	-	Universal Soil Loss Equation
UTV	-	Utility Vehicle

1.0 INTRODUCTION

The United States Department of the Interior (USDOI) Bureau of Land Management (BLM) administers about 247.9 million acres in 17 western states in the continental United States (U.S.) and Alaska. One of the BLM's highest priorities is to promote ecosystem health, and one of the greatest obstacles to achieving this goal is the rapid expansion of invasive plants (including noxious weeds and other plants not native to an area) across public lands. These invasive plants can dominate and often cause permanent damage to natural plant communities. If not eradicated or controlled, invasive plants will jeopardize the health of public lands and the activities that occur on them. Herbicides are one method employed by the BLM to control these plants.

1.1 Background

In 2007, the BLM published the *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic Environmental Impact Statement* (17-States PEIS; USDOI BLM 2007a). The Record of Decision (ROD) for the 17-States PEIS allowed the BLM to use 18 herbicide active ingredients available for a full range of vegetation treatments in 17 western states (USDOI BLM 2007b). In the ROD, the BLM also identified a protocol for identifying, evaluating, and using new herbicide active ingredients (see Appendix A of the ROD). Under the protocol, the BLM would not be allowed to use a new herbicide active ingredient until 1) the agency assessed the hazards and risks from using the new herbicide active ingredient, and 2) prepared an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA) to assess the impacts of using the new herbicide active ingredient on the natural, cultural, and social environment. A final decision on whether a new active ingredient was approved would be recorded in the EIS ROD.

This Human Health Risk Assessment (HHRA) evaluates the risk to humans from two herbicide active ingredients that the BLM is using, and three that it is proposing for use on public lands. The two herbicides that the BLM is using are 2,4-D and clopyralid. For 2,4-D and clopyralid, the BLM has relied upon the HHRA risk assessments conducted on behalf of the United States Department of Agriculture (USDA) Forest Service. This HHRA also provides information for three new herbicides that the BLM proposes to use: aminopyralid, fluroxypyr, and rimsulfuron

These active ingredients may be formulated into herbicides under a variety of trade names and manufacturers. Therefore, specific trade names and manufacturers are not discussed in this report, other than to provide reference herbicide labels (Appendix A). This HHRA evaluates the risks to humans from these five active ingredients only. Other active ingredients that the BLM is currently using have already been quantitatively evaluated in the 17-States PEIS.

1.2 Human Health Risk Assessment Overview

This HHRA follows human health risk assessment guidelines developed by the National Academy of Sciences (NAS 1983), the U.S. Environmental Protection Agency (USEPA) Superfund program (USEPA 1989), and the USEPA Office of Pesticide Programs (OPP; USEPA 2000). While the original scope of work for AECOM's (formerly ENSR) development of the 2005 HHRA stated that the template for the report, exposure scenarios, and evaluation would be obtained from the previous EISs, in 2002 the BLM convened an interagency work group to review these methods and compare them with current risk assessment practices. The ultimate goal of these discussions was to reach consensus on an updated risk assessment methodology to be used in the HHRA that is scientifically defensible, is consistent with currently available guidance where appropriate, and meets the needs of the BLM vegetation treatment program.

For the HHRA methods discussions, the interagency work group consisted of representatives from the following institutions:

- Bureau of Land Management (Gina Ramos, Brian Amme, Karl Ford, Richard Lee, Hank McNeel)

- ENSR International (now AECOM), BLM contractor (Lisa Bradley - HHRA Team Lead, Stuart Paulus - Project Manager)
- U.S. Environmental Protection Agency - Office of Pesticide Programs (Jeff Evans)

The HHRA complies with USEPA guidance for conducting risk assessments for pesticides including, but not limited to, guidance provided in the following documents:

- Guidance for Performing Aggregate Exposure and Risk Assessments (USEPA 1999a)
- The Role of Use-Related Information in Pesticide Risk Assessment and Risk Management (USEPA 2000)
- Exposure Factors Handbook (EFH; USEPA 2011a)
- Science Advisory Council for Exposure Policy 3 (USEPA 2011b)
- Standard Operating Procedures (SOPs) for Residential Pesticide Exposure Assessment (USEPA 2012a)

1.3 Organization of Document

The HHRA follows the four-step paradigm identified by the NAS (1983):

- Hazard Identification
- Dose-Response Assessment
- Exposure Assessment
- Risk Characterization

Sections 2.0 to 5.0 of this HHRA discuss these steps and provide results, as appropriate. Section 6.0 provides a summary of the document and conclusions, and Section 7.0 lists the references.

2.0 HAZARD IDENTIFICATION

The purpose of the hazard identification process is to identify and summarize toxicity information for the five herbicide active ingredients being evaluated in this HHRA.

2.1 Chemical Characteristics and Usage

This section provides simple chemical descriptions and usage summaries for the five herbicide active ingredients.

2.1.1 Aminopyralid

Herbicides using aminopyralid as the active ingredient are liquid soluble concentrate formulations in which aminopyralid is formulated as the triisopropanol-ammonium (TIPA) salt. The product with the highest concentration contains 40.6% aminopyralid TIPA salt at an acid equivalent (a.e.) of 21.1% or 2 lbs a.e./gallon. According to several manufactures' labels (see Appendix A), these herbicides are used for the control of herbaceous broadleaf weeds and certain woody plants. Aminopyralid is a pyridine carboxylic acid herbicide with auxin-like qualities. The herbicide deregulates plant growth metabolic pathways, ultimately impacting growth and causing death of susceptible plant species (USEPA 2009a).

2.1.1 Clopyralid

Clopyralid is registered for use on a variety of food and feed crops in the U.S. for the postemergence control of broadleaf weeds, particularly thistles and clover (see label in Appendix A). Clopyralid is an herbicide of the pyridinoxy acid chemical group. It is structurally similar to plant auxins and acts as an "auxin imitator," disrupting plant growth by binding to auxin receptors (USEPA 2009b). The herbicide active ingredient is in a liquid formulation.

2.1.2 2,4-D

Herbicides using 2,4-D as the active ingredient include wettable powders, granules, soluble concentrates in both liquid and solid forms, and emulsifiable concentrates. Several manufacturers' labels are included in Appendix A. These formulations are typically applied as broadcast, banded, or directed (spray or wiper) applications during dormancy or preplant, preharvest, preemergence, emergence, postemergence, or postharvest, using ground or aerial equipment. The mechanisms of action for 2,4-D are thought to be by increasing cell-wall plasticity, increasing protein biosynthesis, and increasing ethylene production. These increases appear to result in uncontrolled cell division and growth, which ultimately damages vascular tissue (USEPA 2005a).

2.1.3 Fluroxypyr

Herbicides using fluroxypyr as the active ingredient are liquid formulations with an emulsifiable concentrate formulation of fluroxypyr 1-methylheptyl ester (MHE). According to several manufactures' labels (see Appendix A), these herbicides are used for selective postemergence control of annual and perennial broadleaf weeds and for the control of woody plants and annual and perennial broadleaf weeds. Fluroxypyr is in the pyridinoxy acid chemical group and induces auxin-type responses in susceptible broadleaf weeds (USEPA 2003a).

2.1.1 Rimsulfuron

Herbicides using rimsulfuron as the active ingredient are used to control weeds in various crops (see Appendix A). Formulations include dry flowable and water soluble granules. Rimsulfuron is a sulfonylurea herbicide (USEPA 2011c). Inhibition of the acetolactate synthase enzyme leads to rapid cessation of plant growth as well as visual symptoms such as chlorosis, necrosis, leaf malformation, and discoloration.

2.2 Toxicity Profiles

This section includes toxicity profiles that summarize the potential toxicity of each of the herbicide active ingredients and provide information that puts the toxicity into context. The toxicity profiles present information derived from acute, subchronic (less than or equal to 1/10 of lifetime), and chronic toxicity studies (greater than 1/10 of lifetime); reproductive and developmental toxicity studies; cancer bioassays; mutagenicity studies; epidemiology studies; metabolic studies; and toxicokinetic studies. Dose-response assessments based on available toxicity information are discussed in Section 3.0.

Much of the toxicity information discussed in this section is summarized from HHRAs that were prepared by the USEPA OPP Health Effects Division (HED) to evaluate use of the herbicides on specific crops. These studies are referenced in USEPA documents using Master Record Identification (MRID) numbers. Due to the confidential business information (CBI) status of much of the MRID-referenced information, the USEPA reports are the primary references for this review, as the MRID-referenced documents are not publically available.

In addition, a literature search was conducted to determine whether more recent materials are available that might provide additional information for the toxicity endpoints selected by the USEPA for risk assessment (see Section 3.0) or updated information regarding endocrine disruption. The databases searched include the National Library of Medicine's Hazardous Substances Data Bank (HSDB) and Toxline. More recent studies than those used by the USEPA to develop the dose-response values were not identified for aminopyralid, clopyralid, fluroxypyr, or rimsulfuron. While the literature review revealed newer studies on 2,4-D, a review of the abstracts revealed that one study (Sturtz et al. 2010) evaluated doses lower than the current endpoint of 5 milligrams per kilogram of body weight per day (mg/kg-day) selected by the USEPA for evaluation of chronic dietary effects and long-term dermal and inhalation effects (see Section 3.2.3). Therefore, the Sturtz et al. study was reviewed and is summarized below.

The goal of the Sturtz et al. study was to determine if exposure to 2,4-D would result in alterations in milk transfer from maternal rats to pups. Female rats were treated with doses of 2,4-D of 2.5, 5, 10, 15, 25, 50, or 70 mg/kg-day for 16 days beginning the day after giving birth to a litter of pups. The mother and pups were evaluated to determine whether there was a relationship between the dose of 2,4-D and milk transfer from the mother to her nursing pups. The changes in the pups' weights during the suckling period were monitored as a measure of the amount of milk ejected by the mother. The mothers' hormone levels associated with milk ejection and secretion were also measured. The results of the study indicated that the pups that were nursed by mother rats treated chronically via the lowest administered daily oral dose of 2.5 mg/kg-day 2,4-D had a significant reduction in body weight. This dose (2.5 mg/kg-day) also resulted in a significant inhibition of prolactin, the hormone involved in milk secretion, in mother rats. Therefore, based on the results of this study, chronic exposure to 2.5 mg/kg-day of 2,4-D produced a significant inhibition in milk transfer to the litter of lactating rats. This study was not yet published and therefore was not included in the USEPA's literature review when establishing the No Observable Adverse Effect Level (NOAEL) of 5 mg/kg-day and resulting RfD for 2,4-D.

Where information is available for both the salt and the acid forms of the various active ingredients, the information for the acid form is presented. The acid forms tend to be used more often in commercial products and tend to have higher toxicity than the salt forms.

Each of the toxicity profiles includes information on acute toxicity. As shown in Table 2-1, the USEPA has developed toxicity categories (I through IV) for pesticides based on acute (1 to 7 days) toxicity animal tests conducted in support of registration of the pesticides (USEPA 2003b).

Acute toxicity studies are used to determine oral, dermal, inhalation, and eye toxicity endpoints based on a single dose or several large doses of a substance. An important endpoint in acute testing is the toxicity reference level known as the median lethal dose (LD_{50}), which is the dose, usually administered orally, that kills 50% of the test animals. The lower the LD_{50}, the greater the toxicity of the chemical. In addition to the lethal doses, the USEPA uses a battery of laboratory toxicity studies to determine skin and eye effects. The USEPA defines each toxicity endpoint with one of four toxicity categories (I through IV), with higher numbered categories representing lower acute toxicity, as indicated in Table 2-1.

In longer-term toxicity studies (chronic or subchronic), the endpoints for evaluation are the NOAEL and the lowest dose at which an adverse effect has been observed, called a Lowest Observable Adverse Effect Level (LOAEL). Where both levels can be identified in a single study, for a given effect, the LOAEL is always higher than the NOAEL. In some studies, adverse effects are observed at all dose levels; in these cases, the lowest dose tested is identified as the LOAEL. By contrast, where no adverse effects are seen at any dose level tested, the highest dose tested (also referred to as the limit dose) is identified as the NOAEL. NOAELs are identified for short-, intermediate-, and long-term time frames. In the current USEPA OPP program, short-term is defined as up to 30 days, intermediate-term is defined as 1 to 6 months, and long-term is defined as greater than 6 months (USEPA 2012a). Subchronic exposures are defined as those lasting less than 1/10 of a lifetime, while chronic exposures are defined as those lasting longer than 1/10 of a lifetime (USEPA 1989). Note that the time-frame for subchronic and chronic exposures is dependent on the species. For humans, subchronic exposures are those lasting fewer than 7 years and chronic exposures are those lasting longer than 7 years, assuming a 70-year lifetime. Therefore, based on the OPP program exposure times, both short- and intermediate-term exposures are subchronic, while long-term exposures may be either subchronic or chronic.

2.2.1 Aminopyralid

Aminopyralid has low acute toxicity via oral, dermal, and inhalation routes of exposure; however, the free acid form of the molecule produces severe eye irritation. The stomach, ileum, and cecum appear to be targets for this chemical. At mid- and high-level doses, ulcers and erosion of the mucosal lining have been noted in the stomach. At high level doses, effects on the mucosal lining of the ileum and cecum have been observed. Developmental and reproduction studies show no evidence of increased qualitative or quantitative susceptibility of the fetuses or offspring to aminopyralid. Dermal studies indicate that aminopyralid does not have significant toxicity via the dermal route of exposure. Aminopyralid has been classified as “not likely to be carcinogenic to humans,” and there is no evidence that aminopyralid is mutagenic or an endocrine disruptor (USEPA 2009a).

2.2.1.1 Acute Toxicity

Table 2-2 lists the toxicity categories for aminopyralid. Toxicity studies are available for both the salt and the acid forms of aminopyralid. Both the acid and the salt forms result in low acute toxicity by oral, dermal, and inhalation routes of exposures, as well for skin irritation (all studies are in Toxicity Category IV), and neither form is a dermal sensitizer. However, the acid form is an eye irritant (Toxicity Category I), while the salt form has low acute toxicity (Category IV; USEPA 2009a).

2.2.1.2 Subchronic Toxicity

Oral

Toxicity information for subchronic oral exposure to aminopyralid comes from subchronic feeding studies (90 days) of rats, mice, and dogs, and a subchronic oral study of rats conducted with aminopyralid TIPA. A range of doses were tested. No adverse effects were observed in the aminopyralid mouse study or the aminopyralid TIPA salt rat study. NOAELs of 500 mg/kg-day (males) and 1,000 mg/kg-day (females) were identified in the aminopyralid rat study. The LOAEL for males was 1,000 mg/kg-day, based on hyperplasia of the mucosal epithelium of the ileum and cecum, and a LOAEL for females was not identified. NOAELs of 282 mg/kg-day (male) and 232 mg/kg-day (female) were identified in the aminopyralid dog study. LOAELs of 1,070 mg/kg-day (male) and 929 mg/kg-day (female) were identified based on stomach histopathology (slight diffuse hyperplasia and hypertrophy of the mucosal epithelium). These NOAELs are higher than the NOAEL of 104 mg/kg-day selected by the USEPA (see Section 2.2.1.3) as the endpoint for incidental oral and inhalation risk assessment based on developmental effects (USEPA 2009a).

Dermal

Toxicity information for subchronic dermal exposure to aminopyralid comes from a 28-day dermal toxicity study in rats. Applied doses ranged from 0 to 1,000 mg/kg-day. Systemic toxicity was not observed, but slight epidermal hyperplasia was observed in males at doses of 1,000 mg/kg-day. Based on the lack of systemic effects, the USEPA determined that a dermal endpoint for risk assessment was not required (USEPA 2009a).

Inhalation

Subchronic inhalation studies with aminopyralid are not available, and the USEPA has determined that such studies are not required (USEPA 2009a).

2.2.1.3 Developmental Toxicity

Developmental toxicity information for aminopyralid comes from several studies with rats and rabbits with both aminopyralid and aminopyralid TIPA salt. A range of doses were tested. No effects were observed in the rat studies. Effects were observed in the rabbit studies, with effects observed at lower doses in the study with the aminopyralid TIPA salt. In that study, rabbits were administered doses of 0, 200, 500, and 1,000 mg/kg-day aminopyralid TIPA salt (acid equivalent doses of 0, 104, 260, 520 mg a.e./kg-day). At the maternal dose of 260 mg a.e./kg-day, severe inanition (exhaustion from lack of food), body weight loss, decreased fecal output, and incoordinated (lacking coordination) gait were observed. At 520 mg a.e./kg-day, decreased fetal body weights were observed. The USEPA selected the NOAEL of 104 mg a.e./kg-day from this study as the endpoint for short- and intermediate-term oral exposures, and based on route-to-route extrapolation, for short- and intermediate-term inhalation exposures (USEPA 2009a).

2.2.1.4 Reproductive Toxicity

No adverse effects were observed in a two-generation reproduction study conducted in rats with aminopyralid (USEPA 2009a).

2.2.1.5 Chronic Toxicity/Carcinogenicity

Chronic toxicity/carcinogenicity information for aminopyralid comes from a 1-year feeding study of dogs, a 2-year toxicity/carcinogenicity study of rats, and an 18-month carcinogenicity study of mice. No increases in tumors were observed in these studies. However, systemic effects were observed in both the dog and the rat study. The USEPA selected the NOAEL of 50 mg/kg-day from the rat study as the NOAEL for chronic dietary exposures. At the LOAEL of 100 mg/kg-day, cecal enlargement, slight mucosal hyperplasia of the cecum in males, and slightly decreased body weights were observed (USEPA 2009a).

2.2.1.6 Mutagenicity

Aminopyralid and aminopyralid TIPA salt were negative in the following mutation assays: bacterial reverse mutation assays, *in vitro* mammalian cell gene mutation tests, and mammalian erythrocyte micronucleus tests. In an *in vitro* chromosome aberration assay in Sprague Dawley rats, aminopyralid induced chromosome aberrations, but only at cytotoxic concentrations. The clastogenic response was induced secondary to toxicity. Aminopyralid TIPA salt was negative in an *in vitro* chromosome aberration assay (USEPA 2009a).

2.2.1.7 Neurotoxicity

There was no evidence of neurotoxicity in acute or chronic neurotoxicity studies in rats. Urine and fecal soiling were observed at a high dose (2,000 mg/kg-day) in the acute study. No effects were observed in the chronic study. While incoordinated gait and a lack of ambulatory movement was observed in a developmental study in rabbits, these effects were more likely an indication of overt toxicity and not a result of neurotoxicity. Signs of neurotoxicity were not observed in other studies, and no evidence of quantitative or qualitative susceptibility was observed in developmental toxicity studies in rats or rabbits or in a reproduction study in rats. Therefore, the USEPA has not required a developmental neurotoxicity study (USEPA 2009a).

2.2.1.8 Immunotoxicity

No immunotoxicity studies are available for aminopyralid. However, the available studies for aminopyralid do not show any evidence of treatment-related effects on the immune system. The overall weight of evidence suggests that this chemical does not directly target the immune system. While an immunotoxicity study is required, the USEPA does not believe that such a study will result in a lower NOAEL than that currently used for overall risk assessment (USEPA 2009a).

2.2.1.9 Metabolism

In metabolism studies in rats, aminopyralid is rapidly absorbed, distributed, and excreted following oral administration. Study results indicate that aminopyralid is not metabolized to volatile compounds, including carbon dioxide. Tissue distribution and bioaccumulation of aminopyralid appears to be minimal. When administered orally to rats, aminopyralid and aminopyralid TIPA salt are bioequivalent in terms of absorption, distribution, metabolism, and excretion of the aminodichloro-picolinate portion of the molecule (USEPA 2009a).

2.2.1.10 Endocrine Disruption

The USEPA developed the Endocrine Disruptor Screening Program (EDSP) to determine whether certain substances (including pesticide active and other ingredients) “may have an effect in humans that is similar to an effect produced by naturally occurring estrogen, or other such endocrine effects as the Administrator [of the USEPA] may designate.” The EDSP is a two-tiered screening and testing strategy, in which Tier 1 screening is used to identify chemicals that could be endocrine disruptors based on a battery of 11 assays. Only chemicals identified under Tier 1 to have potential endocrine activity will advance to Tier 2, which will include further testing to determine a dose-response relationship (USEPA 1998a). The USEPA announced the initial list of chemicals to be screened under Tier 1 for their potential effects on the endocrine system on April 15, 2009, and the second list on November 17, 2010. Aminopyralid was not identified for Tier 1 screening on either list.

2.2.2 Clopyralid

Clopyralid has low acute toxicity by oral and dermal exposure, and inhalation, but is a severe eye irritant. It is not a dermal sensitizer. While effects have been noted in various organs and systems, including increases in liver weight, changes in clinical chemistry and blood cell parameters, skin lesions, and decreases in body weight gain, a mammalian target organ has not been identified. There is no evidence of increased pre- or post-natal sensitivity to clopyralid. No adverse dermal effects have been noted, even at the highest dose tested. There are no indications of neurotoxic or immunotoxic activity, and clopyralid has been classified as not likely to be carcinogenic to humans. Endocrine disruption studies have not been conducted (USEPA 2009b).

2.2.2.1 Acute Toxicity

Table 2-2 lists the toxicity categories for clopyralid. Clopyralid has low acute toxicity by oral, dermal, and inhalation routes of exposure (all studies are in Toxicity Category IV). However, clopyralid, in its acid form, is an eye irritant (Toxicity Category I). Clopyralid is not a dermal sensitizer (USEPA 2009b).

2.2.2.2 Subchronic Toxicity

Oral

Toxicity information for subchronic oral exposure to clopyralid comes from a 90-day feeding study with mice. Subchronic feeding studies with rats and dogs have not been conducted, as this requirement was satisfied by the subchronic study with mice and the chronic studies with rats and dogs. In the subchronic mouse study, a NOAEL was identified at 2,000 mg/kg-day, based on decreased body weight gain observed at the LOAEL, which was the highest dose tested (5,000 mg/kg-day). As the NOAEL from this study is much higher than that described for maternal toxicity described in Section 2.2.2.4, it was not selected by the USEPA as an endpoint for human health risk assessment (USEPA 2009b).

Dermal

Toxicity information for subchronic dermal exposure to clopyralid comes from a 21-day dermal toxicity study of rabbits. Doses ranging from 0 to 1,000 mg/kg-day were tested. No effects were observed at the highest dose tested, and no local dermal irritation was observed. Therefore, the USEPA concluded that dermal risk assessment is not necessary (USEPA 2009b).

Inhalation

A subchronic inhalation study for clopyralid is not available. The USEPA requires such a study if there is a likelihood of significant repeated inhalation exposure to a pesticide as a gas, vapor, or aerosol. However, the USEPA has waived the subchronic inhalation study for rimsulfuron (J. Evans, USEPA OPP personal communication, February 11, 2014). In the absence of this information, the USEPA has used the oral mouse study described in Section 2.2.2.5 to estimate inhalation toxicity via route-to-route extrapolation.

2.2.2.3 Developmental Toxicity

Developmental toxicity information for clopyralid comes from studies with rats and rabbits. Maternal effects were observed in both studies, while developmental effects were observed only in the rabbit study. Effects were observed at lower levels in the rat study, from which the USEPA selected the NOAEL to assess human health risks from acute dietary exposures as well as short-term incidental oral and inhalation exposures. In the rat study, pregnant Fischer 344 rats were administered clopyralid (97.0% active ingredient [a.i.]) by gavage at 0, 15, 75 or 250 mg/kg-day from gestation on days 6 through 15. A repeat study evaluating control and high doses was conducted to assess a low level of malformations in the initial study at the high dose. Maternal toxicity was observed at the LOAEL of 250 mg/kg-day, based on mortality, decreased body weight gains, and decreased food consumption. The maternal NOAEL was 75 mg/kg-day. No developmental toxicity was observed; the NOAEL for developmental effects was 250 mg/kg-day and the LOAEL was not established (>250 mg/kg-day). The maternal NOAEL of 75 mg/kg-day has been selected by the USEPA (USEPA 2009b).

2.2.2.4 Reproductive Toxicity

Reproductive toxicity information for clopyralid comes from a 2-generation rat reproduction study in which clopyralid (96.7% a.i.) was administered in the diet at doses ranging from 0 to 1,500 mg/kg-day for two mating generations. Parental toxicity was observed at the LOAEL of 1,500 mg/kg-day as decreases in body weights, body weight gains and food consumption, and slight focal hyperkeratotic changes in the gastric squamous mucosa. The parental toxicity NOAEL was 500 mg/kg-day. Offspring toxicity was observed at the LOAEL of 1,500 mg/kg-day, based on decreased pup body weight and increased relative liver weights. Reproductive toxicity was not observed; the NOAEL was 1,500 mg/kg-day and a LOAEL was not identified (>1,500 mg/kg-day). The NOAEL identified in this study is higher than the NOAELs selected by the USEPA for dietary and incidental oral/inhalation effects (USEPA 2009b).

2.2.2.5 Chronic Toxicity/Carcinogenicity

Chronic toxicity/carcinogenicity information for clopyralid comes from a 1-year study in which clopyralid was administered by capsule to dogs, a 2-year carcinogenicity feeding study with mice, and a 2-year combined chronic toxicity/carcinogenicity feeding study with rats. Doses ranged from 0 to 2,000 mg/kg-day. No evidence of carcinogenicity was observed in the carcinogenicity studies. Systemic effects were observed in all three studies, including blood effects, increased liver weights, clinical chemistry changes, skin lesions at high doses, decreased body weights/weight gain and decreased food efficiency, and gastric lesions. The rat study yielded the lowest NOAEL of

15 mg/kg-day, based on gastric lesions (epithelial hyperplasia and thickening of the limiting ridge) observed at 150 mg/kg-day (the LOAEL). The USEPA selected this NOAEL for evaluation of chronic dietary effects, as well as for intermediate- and long-term incidental oral and inhalation exposure (USEPA 2009b).

Technical grade clopyralid contains low levels of hexachlorobenzene. Hexachlorobenzene is classified as a potential human carcinogen. The USDA Forest Service included a detailed evaluation of the potential health risks associated with the low levels of hexachlorobenzene in clopyralid in its risk assessment, and concluded that potential risks do not appear to be significant (Syracuse Environmental Research Associates, Inc. [SERA] 2004).

2.2.2.6 Mutagenicity

There was no concern for mutagenicity based on the following mutation assays: *in vitro* and *in vivo* host mediated assays in *Salmonella* and *Saccharomyces*, *in vivo* micronucleus rat assay, unscheduled deoxyribonucleic acid synthesis, rat hepatocytes, and dominant lethal assay in rats.

2.2.2.7 Neurotoxicity

Acute, chronic, and developmental neurotoxicity studies are not available; however, there is low concern for neurotoxicity. Neuropathology (hydrocephalus) was observed in the rabbit developmental study, but only at a dose that caused severe maternal toxicity, and no evidence of neurotoxicity was observed in the rat developmental or reproduction studies or in the available subchronic or chronic studies. Therefore, the USEPA does not recommend that a developmental neurotoxicity study be required. Acute and chronic neurotoxicity studies were identified as required by the USEPA (USEPA 2009b).

2.2.2.8 Immunotoxicity

There were no indications of immunotoxicity in the subchronic or chronic toxicity studies available at doses up to or beyond the limit dose of 1,000 mg/kg-day. An immunotoxicity study was identified as required by the USEPA (USEPA 2009b).

2.2.2.9 Metabolism

A rat metabolism study indicates rapid and essentially complete absorption and excretion, but essentially no metabolism occurs; only the unchanged parent compound is recovered (USEPA 2009b).

2.2.2.10 Endocrine Disruption

Clopyralid was not selected by the USEPA to be screened for potential effects on the endocrine system under the EDSP Tier 1 screening.

2.2.3 2,4-D

The majority of the information presented in the toxicity profile below for 2,4-D was compiled from the Re-registration Eligibility Document (RED, USEPA 2005a) and the HED human health risk assessment in support of the RED (USEPA 2005b). Several data gaps were identified in the RED, and as of February 2010 all data requirement or data gap studies have been submitted. Where possible, data from these unpublished studies are summarized based on USEPA reports, reports submitted to the USEPA, or the Industry Task Force on 2,4-D website (Available at URL: www.24d.org).

Nine forms of 2,4-D are components of a registered pesticide product. Chemical forms include the acid form, sodium salt, alkylamine salts, and esters, as follows:

- 2,4-D acid
- 2,4-D sodium salt

- 2,4-D diethanolamine salt
- 2,4-D dimethylamine salt
- 2,4-D isopropylamine salt
- 2,4-D triisopropanolamine salt
- 2,4-D 2-butoxyethyl ester
- 2,4-D 2-ethylhexyl ester
- 2,4-D isopropyl ester

With very few exceptions, the effects and relative toxicities of the salt and ester forms of 2,4-D are quite similar to those of the acid form. Thus, the USEPA selected the acid form as being representative of all members of the 2,4-D re-registration case (USEPA 2005b).

Acute toxicity data indicate that 2,4-D in its various forms is not very toxic via oral, dermal, or inhalation routes of exposure. Data indicate that 2,4-D is not a skin sensitizer, but is slightly irritating to the skin. Ester forms are not eye irritants, but the acid and salt forms are severe eye irritants. Primary target organs after subchronic exposure are the eye, thyroid, kidney, adrenals, and ovaries/testes. Systemic toxicity has not been observed after dermal exposure to the acid form, but liver toxicity and one female animal death have occurred following repeated high dose dermal exposure to salt forms of 2,4-D. Developmental toxicity has been observed in rats and rabbits. Reproductive toxicity has also been observed. There have been concerns for endocrine disruption. Neurotoxicity has also been observed at relatively high dose levels. Based on the results of an extended one-generation study submitted to the USEPA (MRID 47972101, as summarized in Neal et al. [2010]), there is no evidence of reproductive toxicity, developmental neurotoxicity, or developmental immunotoxicity. There were no effects on estrogen-sensitive endpoints. Significant exposure-related changes in reproductive organ weights were not observed, nor were effects on androgen-sensitive endpoints. Therefore, 2,4-D does not show evidence of causing endocrine disruption.

2,4-D is classified as a Group D chemical (not classifiable as to human carcinogenicity). Based on the overall pattern of responses observed in both *in vitro* and *in vivo* genotoxicity tests, 2,4-D is not mutagenic, although some cytogenic effects have been observed (USEPA 2005b).

2.2.3.1 Acute Toxicity

Table 2-2 lists the toxicity categories for 2,4-D in the acid form. The acute toxicity data indicate that the various forms of 2,4-D are not very toxic via oral (Toxicity Category III), dermal (Toxicity Category III), or inhalation (Toxicity Categories III and IV) routes of exposure. The available data show the various forms of 2,4-D to be slightly irritating to the skin, but not skin sensitizers. Although the ester forms are not eye irritants, the acid and salt forms are considered to be severe eye irritants. Acute toxicity of 2,4-D amine salts and esters is virtually identical to that of 2,4-D acid (USEPA 2005b).

2.2.3.2 Subchronic Toxicity

<u>Oral</u>

Toxicity information for subchronic oral exposure to 2,4-D comes from a 90-day oral toxicity study with rats and two studies with beagle dogs. Doses ranged from 0 to 300 mg/kg-day. Effects were observed in all three studies, including decreased body weight, decreased body weight gain, blood chemistry effects, cataract formation, decreased food consumption, and decreased testes weight in males. NOAELs observed ranged from 1 mg/kg-day in the dog studies (LOAELs of 3 and 3.75 mg/kg-day) to 15 mg/kg-day in the rat study (LOAEL of 100 mg/kg-day). The NOAEL of 15 mg/kg-day based on the rat study was selected by the USEPA (2005b) as the intermediate-term oral, dermal, and inhalation NOAELs for use in risk assessments. At the LOAEL of 100 mg/kg-day, decreased body weight gain, alterations in some hematology and clinical parameters, and cataract formation were observed. As discussed in Section 2.2.3.5, the rat is the more relevant species with respect to human health risk; therefore, the USEPA selected the NOAELs from the rat study.

The USEPA selected a NOAEL from a developmental study to evaluate acute dietary and short-term effects (see Section 2.2.3.3).

Dermal

Toxicity information for subchronic dermal exposure to 2,4-D comes from a 21-day dermal toxicity study with rabbits. Doses ranged from 10 mg/kg-day to 1,000 mg/kg-day, and no effects were observed at the limit dose of 1,000 mg/kg-day. Therefore, both the NOAEL and the LOAEL were set to 1,000 mg/kg-day. The USEPA assigned dermal NOAELs for short, intermediate, and long-term exposure to 2,4-D based on oral studies, as follows:

- Short-term - 25 mg/kg-day (based on rat developmental study, see Section 2.2.3.3)
- Intermediate-term - 15 mg/kg-day (based on rat subchronic feeding study described above)
- Long-term - 5 mg/kg-day (based on a rat chronic toxicity study, see Section 2.2.3.5)

Inhalation

In 2005, no repeated inhalation exposure data were available for 2,4-D. In the absence of inhalation data, the USEPA assigned inhalation NOAELs for short, intermediate, and long-term exposure to 2,4-D based on oral studies, as follows:

- Short-term - 25 mg/kg-day (based on rat developmental study, see Section 2.2.3.3)
- Intermediate-term - 15 mg/kg-day (based on rat subchronic feeding study described above)
- Long-term - 5 mg/kg-day (based on a rat chronic toxicity study, see Section 2.2.3.5)

However, a subchronic (28-day) inhalation study of 2,4-D (USEPA 2005b) was submitted to the USEPA and is summarized in Neal et al. (2010; MRID 47398701). In the study, rats were exposed to concentrations of 2,4-D in air ranging from 0 to 1 mg/liter (L) of air for 28 days. A slight decrease in body weight and body weight gain was observed in females at the 1 mg/L concentration throughout the recovery period. Increased relative kidney weights were also observed. Decreases in body weight and body weight gain were observed in males, but only during the first 2 weeks of the recovery period. The only histopathological changes observed were in the larynx. The USEPA (2010) has accepted this study but has not revised the previously derived inhalation NOAELs based on the new study.

2.2.3.3 Developmental Toxicity

Developmental toxicity information for 2,4-D comes from studies with rats and rabbits. Doses ranged from 0 to 90 mg/kg-day. Maternal and developmental effects were observed in both studies, with NOAELs of 30 mg/kg-day in the rabbit study and 25 mg/kg-day in the rat study. Maternal effects included decreased body weight gains, clinical signs (ataxia, decreased motor activity, loss of righting reflex, cold extremities), and abortion. Developmental effects included skeletal abnormities and abortions. The LOAEL/NOAEL observed in the rat study was lower than that observed in the rabbit study. Therefore, the NOAEL of 25 mg/kg-day from the rat study was selected as the acute dietary NOAEL, as well as the short-term oral, dermal, and inhalation NOAEL. At the LOAEL of 75 mg/kg-day, skeletal abnormalities were observed.

2.2.3.4 Reproductive Toxicity

Reproductive toxicity information for 2,4-D comes from a reproduction and fertility effects study with rats. Doses tested included 0, 5, 20, and 80 mg/kg-day. A parental/systemic NOAEL was identified at 5 mg/kg-day. At the LOAEL of 20 mg/kg-day, decreased female body weight gain and renal tubule alteration in males was observed. A reproductive NOAEL was established at 20 mg/kg-day, based on an increase in gestation length at a LOAEL of 80 mg/kg-day. An offspring NOAEL of 5 mg/kg-day was identified based on an increase in dead pups at a LOAEL of 80 mg/kg-day. Note that the lowest NOAEL identified from this study (5 mg/kg-day) is equivalent to the NOAEL identified in the chronic rat toxicity study (Section 2.2.3.3), which was used to develop NOAELs for chronic dietary and long-term dermal and inhalation exposures. It should also be noted that in an extended 1-generation rat study submitted to the USEPA after the RED was published, there was no evidence of reproductive toxicity (MRID 47972101, as summarized in Neal et al. [2010]).

2.2.3.5 Chronic Toxicity/Carcinogenicity

Chronic toxicity/carcinogenicity information for 2,4-D comes from a chronic toxicity study with dogs, a carcinogenicity study with mice, and a chronic toxicity/carcinogenicity study with rats. Doses ranged from 0 to 300 mg/kg-day. No evidence of carcinogenicity was observed in the carcinogenicity studies. Systemic effects were observed in all three studies, including decreased body weight gain and food consumption, alterations in hematology and clinical chemistry parameters, increased thyroid weights, decreased testes and ovarian weights, decreased brain weight, increased kidney weights, and increased lesions in the eyes, liver, kidneys, adipose tissue, and lungs. The USEPA (2005b) selected the NOAEL from the rat study of 5 mg/kg-day for use in evaluating chronic dietary as well as long-term dermal and inhalation exposures. At the LOAEL of 75 mg/kg-day, decreased body weight gain and food consumption, increased thyroid weights, decreased testes and ovarian weights, as well as alterations in hematology and clinical chemistry parameters were observed. The NOAEL identified in the mouse study was also 5 mg/kg-day, while the NOAEL identified in the dog study was slightly lower, at 1 mg/kg-day. The chronic NOAEL was previously based on the dog study; however, the HED's Hazard Identification Assessment Review Committee concluded that the rat is the more relevant species with respect to human health risk. Dogs have a limited ability to excrete organic acids, and higher blood levels of 2,4-D are attained in the dog relative to the rat. Consequently, effects are observed at lower dose levels in dogs than rats. The plasma half-life of 2,4-D in the human is more similar to the rat than the dog. Furthermore, the dog has a decreased ability to clear 2,4-D relative to other species. Therefore, the selection of the NOAEL from the rat study is appropriate. It should also be noted that in an extended one-generation rat study submitted to the USEPA after the RED was published, the kidney was confirmed as a target organ for 2,4-D and a similar NOAEL was identified (MRID 47972101 as summarized in Neal et al. [2010]).

2.2.3.6 Mutagenicity

The USEPA concluded that there is no concern for mutagenicity resulting from exposure to 2,4-D or its amine salts and esters. Ames tests, with and without metabolic activation, were consistently negative. Negative results were also observed in a mouse bone marrow micronucleus assay and in unscheduled DNA synthesis assays in rat hepatocytes. Conflicting results were obtained in fruit flies; positive effects were observed in larvae, and negative results were observed in adults after feeding or injection. Conflicting results were also seen in *in vitro* mammalian cell cytogenetics assays; 2,4-D was negative for structural chromosomal damage up to an insoluble level but positive in the presence of metabolic activation at high doses. The positive evidence, however, tends to be weak and is generally not supported by the data from *in vivo* cytogenetic assays. Overall, the pattern of responses observed both *in vivo* and *in vitro* indicates that 2,4-D is not mutagenic, although some cytogenetic effects were observed. Consequently, at this time, the possibility of genotoxicity for 2,4-D cannot be ruled out (USEPA 2005b).

2.2.3.7 Neurotoxicity

Neurotoxicity information for 2,4-D comes from acute and subchronic neurotoxicity screening studies with rats. In the acute study, doses of 0, 13, 67, and 227 mg/kg-day were tested, and the NOAEL was identified as 67 mg/kg-day. At the LOAEL of 227 mg/kg-day, there was an increased incidence of incoordination and slight gait abnormalities and decreased total motor activities. Doses of 5, 75, and 150 mg/kg-day were tested in the subchronic study, and the NOAEL was identified as 75 mg/kg-day. At the LOAEL of 150 mg/kg-day, increased forelimb grip strength was observed. The NOAELs identified from these studies are higher than those selected by the USEPA for dietary, oral, dermal, and inhalation exposures. A developmental neurotoxicity study was not available in 2005 and was identified as a data gap (USEPA 2005b). Since that time, an extended 1-generation study with rats was submitted to the USEPA (MRID 47972101) and is summarized in Neal et al. (2010). The design of this study allowed for evaluation of a number of endpoints, including developmental neurotoxicity. There was no evidence of developmental neurotoxicity in the study. The USEPA (2010) classified the study as acceptable. This study is summarized in Section 2.2.3.10.

2.2.3.8 Immunotoxity

Immunotoxicity studies were not available in 2005. Therefore, a repeat 2-generation reproduction study using the new protocol was required by the USEPA to address specific concerns for endocrine disruption (thyroid and immunotoxicity measures; USEPA 2005a). An extended 1-generation study in rats was submitted to the USEPA (MRID 47972101) and is summarized in Neal et al. (2010). The study included evaluation of developmental immunotoxicity as well as systemic toxicity (body and organ weights, gross pathology, histopathology), thyroid toxicity, developmental neurotoxicity, reproductive/endocrine toxicity, and neuropathology. There was no evidence of developmental immunotoxicity in the study. The USEPA classified the study as acceptable (USEPA 2010). This study is summarized in Section 2.2.3.10.

2.2.3.9 Metabolism

In general, 2,4-D undergoes limited metabolism primarily involving minor conjugation of the parent acid that is then excreted in the urine. No detectable metabolites of 2,4-D have been reported from rat studies (that is [i.e.], only the parent acid is found in rat urine). In addition to 2,4-D itself, 2,4-D conjugates have been found in the urine of dogs, humans, mice, and hamsters following oral exposure (USEPA 2005b).

2.2.3.10 Endocrine Disruption

2,4-D was selected for Tier 1 screening for potential effects on the endocrine system under the EDSP. The 2,4-D Task Force submitted a request to the USEPA to use existing information for 9 of the 11 required tests required for Tier 1 screening under the EDSP (Neal et al. 2010). The USEPA responded that it would accept existing data for 4 of the 11 required tests (USEPA 2010). The USEPA stated that the existing data were not sufficient to satisfy three of the required tests, and that if additional information were submitted, the USEPA would reconsider the use of existing data for two of the required tests.

The results of an extended 1-generation study with rats were submitted to the USEPA (MRID 47972101), and are summarized in Neal et al. (2010). The design of this study allowed for evaluation of endocrine disruption, immunotoxicity, and developmental neurotoxicity, which were identified as data gaps in the RED (USEPA 2005a). The 1-generation study is summarized below.

Male and female rats were fed diets containing 0, 5, 15, and 30 mg/kg-day (females) and 40 mg/kg-day (males) 2,4-D in the diet for 4 weeks prior to breeding, with the dosing continuing during breeding. After breeding, the test diets were administered to males for 5 to 7 weeks, and were administered to females through gestation and lactation. Mating of a second generation was not required because reproductive toxicity was not observed; this decision was based on *a priori* established criteria and was reviewed and approved by the USEPA.

As noted previously, the study confirmed that the kidneys are a target for 2,4-D. There was no evidence of reproductive toxicity, developmental neurotoxicity, or developmental immunotoxicity. There were no effects on estrogen-sensitive endpoints. Significant exposure-related changes in reproductive weight organs were not observed. Effects on androgen-sensitive endpoints were also not observed. Therefore, 2,4-D does not show evidence of causing endocrine disruption.

Thyroid effects were not observed at low- and mid-level doses. Slight thyroid changes were observed in one group of pregnant females, but at an exposure level that resulted in nonlinear renal clearance.

Endocrine related effects were also not observed in the 28-day inhalation study (MRID 47398701, as cited in Neal et al. 2010), with the exception of decreased relative ovarian weights in females exposed to 2,4-D concentrations in air of 0.1 and 1 mg/L. Because this effect was not observed at the 0.3-mg/L concentration, it does not appear to be related to the 2,4-D concentration. Furthermore, there were no histopathological changes associated with this finding.

It should be noted that the lowest NOAEL in the 1-generation study was 5.5 mg/kg-day, which is slightly greater than the NOAEL of 5 mg/kg-day previously selected by the USEPA for evaluation of chronic dietary, long-term dermal, and long-term oral exposure. Therefore, the previously selected NOAELs are protective of the endpoints identified in the 1-generation study.

As of June 18, 2003, the USEPA had received all data and was in the process of reviewing the information (USEPA 2013).

2.2.3.11 Biomonitoring

Of the chemicals evaluated in this HHRA, 2,4-D is unique in that biomonitoring data are available. While these data are not necessary for the HHRA, they are presented in the Uncertainty Analysis (Section 5.4.4.2) as additional context for this evaluation.

The strongest predictors of potential exposures in the study were:

- Applicator use of gloves during mixing and application of the herbicide, which reduced exposure greatly;
- Number of acres treated, which increased exposure; and
- Repairing equipment, which increased exposure.

2.2.4 Fluroxypyr

Fluroxypyr has low acute toxicity by the oral and dermal routes and moderate acute toxicity by the inhalation route. It is not irritating to the skin, nor is it a dermal sensitizer; however, it is a mild eye irritant. Subchronic and chronic studies in rats, mice, and dogs indicate that the target organ is the kidney. Developmental studies and reproductive studies in rats indicate maternal toxicity as increased kidney weight, and decreased body-weight gain and food consumption. In developmental studies with both rats and rabbits, deaths at high doses have been observed. There is no evidence (quantitative/qualitative) of increased susceptibility following *in utero* exposure of rats and rabbits to fluroxypyr, or following pre and/or postnatal exposure to rats. Endocrine disruption studies have not been conducted. There is no indication that fluroxypyr is carcinogenic or mutagenic (USEPA 2007). Studies supporting the above information and the dose-response data for fluroxypyr (Section 3.0) are summarized below. Herbicides using fluroxypyr as the active ingredient are liquid formulations with an emulsifiable concentrate formulation of MHE.

Table 2-2 lists the toxicity categories for fluroxypyr in the acid form. The acute toxicity data indicate that fluroxypyr is slightly toxic via the oral (Toxicity Category III) and dermal routes of exposure (Toxicity Category III), and moderately toxic via the inhalation route of exposure (Toxicity Category II). It is not a skin irritant. An eye irritation study and a dermal sensitization study were not available for the acid form; the MHE form is mildly irritating to the eye and is not a dermal sensitizer.

2.2.4.1 Subchronic Toxicity

<u>Oral</u>

Toxicity information for subchronic oral exposure to fluroxypyr comes from feeding studies with dogs (28 days), rats (90 days), and mice (90 days), using the acid form of fluroxypyr. Doses ranged from 0 to 1,500 mg/kg-day. Effects were observed in all three studies, including kidney lesions, increased adrenal weights, increased testes weights, decreased body weight gain, decreased brain weight, increased kidney weight, nephrotoxicity, and death. The lowest NOAEL identified was 50 mg/kg-day in the dog study, based on kidney lesions observed at the LOAEL of 150 mg/kg-day. Because no effects were observed following a single dose and because no developmental effects were observed in any studies, the USEPA did not identify NOAELs for acute dietary or short-term oral/inhalation exposures (USEPA 2007).

Dermal

Toxicity information for subchronic dermal exposure comes from a 21-day dermal toxicity study with rabbits, using fluroxypyr MHE. Doses up to 1,000 mg/kg-day were tested. No effects were observed. Therefore, the USEPA determined that dermal risk assessment is not required (USEPA 2007).

Inhalation

A subchronic inhalation toxicity study is not available, and the USEPA has determined that one is not required (USEPA 2007).

2.2.4.2 Developmental Toxicity

Developmental toxicity information comes from tests with rats and rabbits, using both the acid form of fluroxypyr and fluroxypyr MHE. Developmental effects were not observed in the rat studies at doses up to 600 mg/kg-day, and developmental effects were not observed in the rabbit study using the acid form of fluroxypyr at the highest dose tested (250 mg/kg-day). In the rabbit study using fluroxypyr MHE, increased abortions were observed at the highest dose tested (1,000 mg/kg-day), and a NOAEL of 500 mg/kg-day was identified. Maternal effects were observed in all four studies, based on increased kidney weights, increased maternal deaths, decreased body weight gains, decreased food consumption, and increased abortions. Maternal NOAELs ranged from 250 mg/kg-day to 500 mg/kg-day. These NOAELs were higher than the NOAEL selected by the USEPA for evaluation of human health risks via chronic dietary exposure, incidental oral exposure, and inhalation exposure. Thus, the NOAEL (100 mg/kg-day) selected from the combined chronic toxicity/carcinogenicity study in rats is protective of potential developmental and maternal effects (see Section 2.2.4.6; USEPA 2007).

2.2.4.3 Reproductive Toxicity

Reproductive toxicity information for fluroxypyr comes from a study with rats, using fluroxypyr acid at doses from 0 to 1,000 mg/kg-day. No reproductive toxicity effects were observed. Systemic NOAELs of 100 mg/kg-day (males) and 500 mg/kg-day (females) were identified based on kidney effects at the LOAELs of 500 mg/kg-day (males) and 1,000 mg/kg-day (females). A NOAEL of 500 mg/kg-day was identified for offspring, based on decreased pup weight and body weight gain and slightly lower survival at the LOAEL of 1,000 mg/kg-day. The lowest NOAEL from this study (100 mg/kg-day) is the same as the NOAEL selected by the USEPA for evaluation of human health risks via chronic dietary exposure, incidental oral exposure, and inhalation exposure. Thus, the NOAEL selected from the combined chronic toxicity/carcinogenicity study in rats is protective of the systemic and offspring effects identified in this study (see Section 2.2.4.6; USEPA 2007).

2.2.4.4 Chronic Toxicity/Carcinogenicity

Chronic toxicity/carcinogenicity information comes from an oral toxicity study with dogs, an oral carcinogenicity study with mice, and a combined oral chronic toxicity/carcinogenicity study with rats. The fluroxypyr acid was used in all three studies. There was no evidence of carcinogenicity in the mouse or rat studies. No effects were observed in the dog study at the highest dose tested (150 mg/kg-day). A systemic NOAEL of 300 mg/kg-day was identified in the mouse study based on decreased body weight and body weight gain and kidney effects observed at the LOAEL of 1,000 mg/kg-day. In the rat study, oral doses of 0, 100, 500, and 1,000 mg/kg-day were administered to Fischer 344 rats. At the dose of 500 mg/kg-day, chronic progressive kidney glomerulonephropathy was observed. Therefore, 500 mg/kg-day was identified as the LOAEL, and the next lowest dose, 100 mg/kg-day, was selected as the NOAEL. The USEPA selected the NOAEL from the rat study for the evaluation of chronic dietary effects, incidental effects (short/intermediate term), and inhalation effects (short/intermediate term; USEPA 2007).

2.2.4.5 Mutagenicity

Fluroxypyr MHE was negative in the following assays—bacterial reverse mutation, *in vitro* mammalian cell gene mutation, *in vitro* mammalian chromosome aberration, and mammalian micronucleus (USEPA 2007).

2.2.4.6 Neurotoxicity

No evidence of neurotoxicity was observed in the available developmental, reproduction, subchronic, or chronic studies. The weight of the evidence indicates a lack of concern for developmental neurotoxicity. Therefore, the USEPA has not required a developmental neurotoxicity study (USEPA 2007).

2.2.4.7 Immunotoxicity

An immunotoxicity study of fluroxypyr is not available (USEPA 2007). Based on a review of the existing developmental, reproduction, subchronic, and chronic studies reported in USEPA (2007), no effects from fluroxypyr on the immune system were identified.

2.2.4.8 Metabolism

Oral metabolism studies in rats with fluroxypyr MHE show that fluroxypyr MHE is quantitatively converted to fluroxypyr prior to absorption. Following absorption of fluroxypyr, it is rapidly excreted, principally unchanged, in the urine. A variety of toxicological studies of fluroxypyr, as the acid or methylheptyl ester, have documented similar effects.

2.2.4.9 Endocrine Disruption

Fluroxypyr was not selected by the USEPA to be screened for potential effects on the endocrine system under the EDSP Tier 1 screening.

2.2.5 Rimsulfuron

Rimsulfuron has low acute toxicity orally, by dermal exposure, and by inhalation, but is a moderate eye irritant. It is not a dermal sensitizer. In subchronic and chronic toxicity studies, toxic effects have included decreased body weight and decreased body weight gain, liver and kidney effects, blood effects, stomach effects, testicular effects, and increased mortality. The overall weight of evidence suggests that rimsulfuron does not directly target the immune system. In a developmental toxicity study in rats, no developmental toxicity was seen at the highest dose tested. There is no evidence that rimsulfuron is an endocrine disruptor. Rimsulfuron is classified as “Not Likely a Human Carcinogen,” based on the lack of evidence for carcinogenicity in studies conducted in rats and mice (USEPA 2011c). Studies supporting the above information and the dose-response data for rimsulfuron (Section 3.0) are summarized below.

2.2.5.1 Acute Toxicity

Table 2-2 lists the toxicity categories for rimsulfuron. Rimsulfuron has low acute toxicity by oral, dermal, and inhalation routes of exposures (all studies are in Toxicity Category IV with the exception of eye irritation, which is in Category III). Rimsulfuron is not a dermal sensitizer (USEPA 2011c).

2.2.5.2 Subchronic Toxicity

<u>Oral</u>

Toxicity information for subchronic oral exposure to rimsulfuron comes from subchronic toxicity studies (90 days) with rats, mice, and dogs. In the rat study, decreased body weight gain was observed at the LOAEL of 375 mg/kg-day, and a NOAEL of 75 mg/kg-day was identified. In the dog study, there were urinary volume effects and osmolarity effects at the LOAEL of 125 mg/kg-day, and a NOAEL of 6.25 mg/kg-day was identified. The NOAEL in the mouse study for males was 56.25 mg/kg-day, but no effects were seen in females at the highest dose tested (1,125 mg/kg-day). The LOAEL in males of 225 mg/kg-day was based on increased red blood cell and hemoglobin and decreased body weight gain and food efficiency (USEPA 2011c). The USEPA (2011c) did not derive an oral NOAEL for rimsulfuron, stating “Use pattern does not indicate a need for this risk assessment.”

Dermal

Dermal absorption studies are not available. Therefore, the oral NOAEL of 6.25 mg/kg-day identified in the 90-day dog study is used to assess short- and intermediate-term dermal exposures. A dermal toxicity study is required under the latest guidelines, but the USEPA does not believe the submission of the required studies will result in a lower NOAEL and considers the current studies adequate (USEPA 2011c).

Inhalation

Subchronic inhalation toxicity studies are not available. Therefore, the oral NOAEL of 6.25 mg/kg-day identified in the 90-day dog study is used to assess short- and intermediate-term dermal exposures. The USEPA has not required an inhalation study since potential inhalation exposure is low (USEPA 2011c).

2.2.5.3 Developmental Toxicity

Developmental toxicity information for rimsulfuron comes from studies with rats and rabbits. No effects were observed in the rat study at the highest dose tested of 6,000 mg/kg-day. In the rabbit study, a maternal NOAEL of 170 mg/kg-day was established, based on mortality, abortion, and decreased body weight at the LOAEL of 500 mg/kg-day. For developmental toxicity, the NOAEL was 500 mg/kg-day and the LOAEL was 1,500 mg/kg-day, as only two pups were viable at 1,500 mg/kg-day. These NOAELs are higher than the NOAEL of 11.8 mg/kg-day selected by the USEPA for chronic dietary effects (see Section 2.2.5.5); therefore, the chronic dietary NOAEL is protective of potential developmental effects (USEPA 2011c).

2.2.5.4 Reproductive Toxicity

Reproductive toxicity information for rimsulfuron comes from a 2-generation reproduction study with rats. For parental systemic toxicity, the NOAEL was 165 and 204 mg/kg-day in males and females, respectively, and the LOAEL was 830 and 1,021 mg/kg-day in males and females, respectively, based on decreased body weight gain. Similar effects were observed in offspring at similar or slightly higher doses. For offspring toxicity, the NOAEL was 217 and 264 mg/kg-day in males and females, respectively, and the LOAEL was 1,316 mg/kg-day based on decreased mean body weight in males, decreased body weight gain in females, decreased mean pup weight of the females, decreased daily food consumption in males, and decreased mean number of male pups. Decreased weight was also the key finding for systemic effects. Thus, the toxic effects in offspring occurred at the same dose level as the systemic parental effects. These NOAELs are higher than the NOAEL selected for chronic dietary effects; therefore, the chronic dietary NOAEL is protective of potential developmental effects (USEPA 2011c).

2.2.5.5 Chronic Toxicity/Carcinogenicity

Chronic toxicity/carcinogenicity information for rimsulfuron comes from a chronic oral toxicity study with dogs and carcinogenicity studies with mice and rats. No evidence of carcinogenicity was identified in the mouse or rat study.

In the rat study, rats were administered rimsulfuron in doses of 0, 25, 300, 3,000, and 10,000 parts per million (ppm; 0, 1.0, 11.8, 121, 414 mg/kg-day [males]; 1.38, 17.1, 163, 568 mg/kg-day [females]). The NOAELs for systemic effects were 11.8 mg/kg-day (males) and 163 mg/kg-day (females). The LOAELs of 121 mg/kg-day for males and 568 mg/kg-day for females are based on decreased body weight gain and increased relative liver weights. No evidence of carcinogenicity was identified (USEPA 2011c). The NOAEL of 11.8 mg/kg-day from this study has been selected as the NOAEL for chronic dietary effects (USEPA 2011c).

In the dog study, groups of beagle dogs (five/sex/dose) were fed diets containing rimsulfuron (98.8%) at 0, 50, 2,500, or 10,000 ppm for 1 year. These dose levels were equivalent to approximately 0, 1.6, 81.8, and 342.4 mg/kg-day for males and 0, 1.6, 86.5, and 358.5 mg/kg-day for females, respectively. For males, the NOAEL was 81.8 mg/kg-day and the LOAEL was 342.2 mg/kg-day, based on increased absolute liver and kidney weights, as well as increased incidence of seminiferous tubule degeneration and increased numbers of spermatid giant cells present in the epididymides. For females, the NOAEL was 86.5 mg/kg-day and the LOAEL was 358.5 mg/kg-day, based on decreased mean body weight and body weight gain, increased serum cholesterol levels and alkaline phosphatase activity, increased absolute liver weight, and increased relative liver and kidney weights. The NOAEL identified for systemic effects in the dog study is higher than the NOAEL identified in the rat study described above; therefore, the selected NOAEL from the rat study is protective of effects observed in the dog study.

In the mouse study, the NOAELs for systemic effects were 351 mg/kg-day (males) and 488 mg/kg-day (females). The LOAELs of 1,127 mg/kg-day for males and 1,505 mg/kg-day for females are based on decreased mean body weight in males and females, increased incidence of dilation and cysts in the glandular stomach, and degeneration of the testicular artery and tunica albuginea in males. The NOAEL identified for systemic effects in the mouse study is higher than the NOAEL identified in the rat study described above; therefore, the selected NOAEL from the rat study is protective of effects observed in the mouse study.

2.2.5.6 Mutagenicity

Rimsulfuron was found to be negative in the following two mutation assays: an *in vitro* bacterial gene mutation assay and an *in vitro* mammalian cells mutation assay (USEPA 2011c).

2.2.5.7 Neurotoxicity

No evidence of neurotoxicity was observed in the available developmental, reproduction, subchronic, or chronic studies. While acute and chronic studies are required by the USEPA based on the latest guidelines, the USEPA does not believe that such a study will result in a lower point of departure than what is currently being used for overall risk assessment (USEPA 2011c).

2.2.5.8 Immunotoxicity

Immunotoxicity studies for rimsulfuron are not available. However, other types of studies for the active ingredient do not show any evidence of treatment-related effects on the immune system. The overall weight of evidence suggests that this chemical does not directly target the immune system. While an immunotoxicity study is required, the USEPA does not believe that such a study will result in a lower point of departure than what is currently being used for overall risk assessment (USEPA 2011c).

2.2.5.9 Metabolism

Rimsulfuron is metabolized by cleavage or contraction of the sulfonylurea bridge, leading to the formation of 3-(ethylsulfonyl)-2-pyridinesulfonamide (IN-E9260) or N-(4,6-dimethoxy-2-pyrimidinyl)-N-((3-ethylsulfonyl)-2-pyridinyl) urea (IN-70941). IN-70941 is deamidated to form IN-70942, which is sequentially demethylated and hydroxylated (USEPA 2011c).

The metabolism of ^{14}C-labeled rimsulfuron was studied in male and female rats. Excretion accounted for 93 to 96% of the administered radioactivity, with 58 to 67% appearing in the urine and 20 to 33% in the feces. Tissue distribution of labeled residues was low. Males showed slightly higher hepatic accumulation than females within each test group. Animals in the repeat dose groups also showed a slight accumulation in the spleen. The metabolic profiles were determined using pooled urinary and fecal samples. The highest percentage of the urinary (42 to 55%) and fecal (5 to 16%) radioactivity was attributed to unmetabolized parent compound (USEPA 2011c).

2.2.5.10 Endocrine Disruption

The toxicity studies of rimsulfuron provide no evidence of estrogen, androgen, and/or thyroid mediated toxicity. Rimsulfuron was not selected by the USEPA to be screened for potential effects on the endocrine system under the EDSP Tier 1 screening.

Table 2-1
Acute Toxicity Categories and Definitions

Endpoint	Toxicity Category I	II	III	IV
Acute Oral (Oral LD_{50})	0 to 50 mg/kg	50 to 500 mg/kg	500 to 5,000 mg/kg	> 5,000 mg/kg
Acute Inhalation (Inhalation LC_{50})	0 to 0.2 mg/L	0.2 to 2 mg/L	2 to 20 mg/L	> 20 mg/L
Acute Dermal (Dermal LD_{50})	0 to 200 mg/kg	200 to 2,000 mg/kg	2,000 to 20,000 mg/kg	> 20,000 mg/kg
Primary Eye	Corrosive, corneal opacity not reversible within 7 days	Corneal opacity reversible within 7 days; irritation persisting for 7 days	No corneal opacity; irritation reversible within 7 days	No irritation
Primary Skin	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation at 72 hours

LC_{50} = median lethal concentration
LD_{50}= median lethal dose
mg/kg = milligrams of chemical per kilogram of body weight
mg/L = milligrams of chemical per liter of air
Reference: USEPA 2003b. 40 Code of Federal Regulations. Section 156.62. (7/1/03 edition).

Table 2-2
Toxicity Categories for Short-Term Tests

Herbicide Active Ingredient	Acute Oral (a)	Acute Dermal (a)	Acute Inhalation (a)	Primary Eye (b)	Primary Skin (b)	Dermal Sensitizer	Reference
Aminopyralid	IV	IV	IV	I (acid)/IV (salt)	IV	No	USEPA 2009a
Clopyralid	IV	IV	IV	I	IV	No	USEPA 2009b
2,4-D	III	III	III, IV	I, III, IV	III, IV	No	USEPA 2005a,b
Fluroxypyr	III	III	II	NA	IV	NA	USEPA 2007a
Rimsulfuron	IV	IV	IV	III	IV	No	USEPA 2011c

NA - Not Available from USEPA.

References:

USEPA 2005a. Reregistration Eligibility Decision for 2,4-D. EPA 738-R-05-002. June 2005.
Available at: www.epa.gov/oppsrrd1/REDs/24d_red.pdf.

USEPA 2005b. 2,4-D. HED's Revised Human Health Risk Assessment for the Reregistration Eligibility Decision (RED) Revised to Reflect Public Comments. May 12, 2005.
Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2004-0167-0219.

USEPA 2007. Fluroxypyr: Human Health Risk Assessment to Support Proposed New Uses on Pome Fruits and Millet. Report dated October 3, 2007.
Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2007-0114-0004.

USEPA 2009a. Aminopyralid. Human Health Risk Assessment for the Proposed Use on Field Corn (PP#8F7455). October 22, 2009.
Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0141-0006.

USEPA 2009b. Clopyralid. Human Health Risk Assessment to Evaluate New Uses on Swiss Chard, Bushberry Subgroup (13-07B) and Strawberry (Regional Restriction).
December 3, 2009. Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0092-0005.

USEPA 2011c. Rimsulfuron. Human Health Risk Assessment for Proposed Section 3 Uses on Caneburry and Bushberry. November 4, 2011.
Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2010-1017-0005.

Notes:

(a) - USEPA labeling guidelines acute, oral, dermal, and inhalation effects:

I. Severe: oral LD_{50} 0-50 mg/kg; dermal LD_{50} 0-200 mg/kg; inhalation LC_{50} 0-0.2 mg/L.

II. Moderate: oral LD_{50} 50-500 mg/kg; dermal LD_{50} 200-2000 mg/kg; inhalation LC_{50} 0.2-2 mg/L.

III. Slight; oral LD_{50} 500-5,000 mg/kg; dermal LD_{50} 2,000-20,000 mg/kg; inhalation LC_{50} 2-20 mg/L.

IV. Very slight: oral LD_{50} >5,000 mg/kg; dermal LD_{50} >20,000 mg/kg; inhalation LC_{50} >20 mg/L.

(b) - USEPA labeling guidelines for pesticides applied to skin or eyes:

I. Irreversible corneal opacity at 7 days; corrosive to skin.

II. Corneal opacity reversible within 7 days; severe skin irritation at 72 hours.

III. No corneal opacity; moderate skin irritation at 72 hours.

IV. No irritation to the eyes; mild or slight skin irritation at 72 hours.

3.0 DOSE-RESPONSE ASSESSMENT

The purpose of the dose-response assessment is to identify the types of adverse health effects a chemical may potentially cause, and to define the relationship between the dose of a chemical and the likelihood or magnitude of an adverse effect (response). The dose-response assessment identifies quantitative or numerical dose-response values that are used in risk calculations to derive risk estimates. The dose-response values used in the HHRA were developed by the USEPA.

The USEPA categorizes adverse effects as either potentially carcinogenic or noncarcinogenic (i.e., potential effects other than cancer). Dose-response values for either potentially carcinogenic and noncarcinogenic effects are defined by the USEPA. None of herbicide active ingredients evaluated in this HHRA are designated as potential carcinogens by the USEPA (USEPA 2005a, 2007, 2009a, 2009b, 2011c). Therefore, this toxicity assessment focuses on noncarcinogenic effects.

3.1 Types of Dose-response Values

Under the USEPA OPP guidance (USEPA 2000), noncarcinogenic effects are evaluated differently depending on whether the exposure is dietary or non-dietary, and whether the exposure is residential or occupational, as described below.

3.1.1 Dietary Assessment (Residential)

For noncarcinogenic effects, toxicity is represented by a Population Adjusted Dose (PAD), which may be calculated for acute effects (i.e., acute PAD) or chronic effects (i.e., chronic PAD). A PAD is an acute or chronic reference dose (RfD) divided by the Food Quality Protection Act (FQPA) Safety Factor (SF). Both the RfD and the FQPA are discussed below.

Under the provisions of the FQPA of 1996, the USEPA is directed to consider aggregate exposure, cumulative risk, and additional sensitivity of infants and children. The FQPA safety factor is applied to pesticides that exhibit threshold effects to "take into account potential pre- and post-natal toxicity and completeness of the data with respect to exposure and toxicity to infants and children." In applying the factor, the USEPA takes into account information on the toxicity of the pesticide, as well as the completeness of the toxicity and exposure databases. Generally, FQPA safety factors range from 1 to 10.

Reference doses are derived by identifying a NOAEL, which is obtained from the acute or chronic toxicity studies, and then dividing the NOAEL by the appropriate uncertainty factors (UFs). The NOAEL is typically derived from animal studies where animals are dosed with different amounts of the pesticide (see Section 2.2). Typically for pesticides, a 10-fold factor is applied to account for variation within the human population (interspecies), and an additional 10-fold factor is applied to account for the differences between humans and animals (intraspecies). The following equations show the definitions of PAD and RfD:

$$\text{PAD} = \frac{\text{RfD}}{\text{FQPA SF}}, \text{ where}$$

$$\text{RfD} = \frac{\text{NOAEL}}{\text{Uncertainty Factors}}$$

In the acute PAD calculation, the acute RfD and the NOAEL obtained from an acute toxicity study are used in the equation. For the chronic PAD calculation, the chronic RfD and the NOAEL obtained from a chronic study are used (USEPA 2000).

The dietary exposures evaluated in this risk assessment are ingestion of drinking water, berries, and fish by public receptors. These exposure scenarios are further described in Section 4.0 (Exposure Assessment).

3.1.2 Non-Dietary (Occupational or Residential) Assessment

When evaluating noncancer effects of non-dietary exposures, toxicity is represented by the NOAEL. The NOAEL is divided by the intake rate to calculate a Margin of Exposure (MOE). NOAELs are identified for a variety of exposure durations and exposure routes:

- Short-term oral NOAEL
- Intermediate-term oral NOAEL
- Short-term dermal NOAEL
- Intermediate-term dermal NOAEL
- Long-term dermal NOAEL
- Short-term inhalation NOAEL
- Intermediate-term inhalation NOAEL
- Long-term inhalation NOAEL

In the current USEPA OPP program, short-term is defined as up to 30 days, intermediate-term is defined as 1 to 6 months, and long-term is defined as greater than 6 months (USEPA 2012a). Short-term exposures may be acute (1 to 7 days) or subchronic (up to 7 years). Intermediate-term exposures are subchronic (less than 7 years). Long-term exposures may be subchronic or chronic (greater than 7 years). In a personal communication (J. Evans, USEPA OPP personal communication, February 28, 2011), the USEPA noted that long-term exposure is not of concern for seasonal exposures such as those associated with BLM herbicide applications. However, where long-term NOAELs are available, long-term exposures estimates are derived.

In general, NOAELs decrease as exposure time increases. This is because the dose encountered is a factor of concentration and duration of exposure. A study conducted by the California EPA's Office of Environmental Health Hazard Assessment (OEHHA) indicates that both concentration and time of exposure contribute to the overall severity of toxic effects. In fact, "Haber's Law" states that the product of the concentration and time of exposure required to produce a specific physiologic effect is equal to a constant level or severity of response (California EPA 1999). The USEPA has not developed long-term oral NOAELs, since long-term oral exposure is similar to dietary exposure, which is represented by PADs. The short-term and intermediate-term oral NOAELs are used to represent incidental ingestion exposures, such as ingesting water while swimming. NOAELs represent non-dietary exposures and are used to evaluate the occupational receptors and the public receptors for the following scenarios: dermal contact with spray, dermal contact with foliage, dermal contact with water while swimming, and incidental ingestion of water while swimming. These exposure scenarios are further described in Section 4.0 (Exposure Assessment).

For each of the herbicides evaluated in this HHRA, the USEPA has developed NOAELs for a limited set of exposure durations and exposure routes. In other words, not all of the NOAELs listed above have been developed for all herbicides.

3.1.3 Target Margin of Exposure

The NOAEL divided by the intake results in the MOE. The target MOE accounts for uncertainties in the NOAEL, and is the same as the uncertainty factor. The MOEs calculated in Section 5 are compared to the target MOE.

Calculated MOEs greater than the target MOE indicate no significant risk. In Table 3-1, the target MOE of each active ingredient is listed, along with the dose-response values.

3.1.4 Carcinogen Classification

As noted above, none of the herbicides addressed in this risk assessment have been classified by the USEPA as carcinogens. However, technical grade clopyralid may contain hexachlorobenzene, which is a potential carcinogen. Based on the information provided in SERA (2004), it does not appear that potential contamination of technical grade clopyralid with hexachlorobenzene is associated with significant risks. Therefore, further evaluation of the potential carcinogenic risks associated with hexachlorobenzene in technical grade clopyralid has not been conducted.

The USEPA has developed carcinogen risk assessment guidelines (USEPA 2005c) that revise and replace the previous carcinogen risk assessment guidelines. However, the carcinogen risk assessments for some of the herbicides addressed in this HHRA have used the classification system developed in the previous guidance (USEPA 1999b) because they have not yet been classified under the new system (USEPA 2005c). The classification system in the 1999 guidance was developed according to the weight of evidence from epidemiologic and animal studies:

- Group A - Human Carcinogen (sufficient evidence of carcinogenicity in humans)
- Group B - Probable Human Carcinogen (B1 - limited evidence of carcinogenicity in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)
- Group C - Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data)
- Group D - Not Classifiable as to Human Carcinogenicity (inadequate or no evidence)
- Group E - Evidence of Noncarcinogenicity for Humans (no evidence of carcinogenicity in adequate studies)

The USEPA (2005c) currently uses a weight of evidence narrative rather than the classification system that was used in the previous guidance. The following descriptors are recommended along with the weight of evidence narrative:

- Carcinogenic to humans - this descriptor indicates strong evidence of human carcinogenicity.
- Likely to be carcinogenic to humans - this descriptor is appropriate when the weight of evidence is adequate to demonstrate carcinogenic potential to humans.
- Suggestive evidence of carcinogenic potential - this descriptor is appropriate when the weight of evidence is suggestive of carcinogenicity; a concern for potential carcinogenic effects in humans is raised, but the data are judged not sufficient for a stronger conclusion.
- Inadequate information to assess carcinogenic potential - this descriptor is appropriate when available data are judged inadequate for applying one of the other descriptors.
- Not likely to be carcinogenic to humans - this descriptor is appropriate when the available data are considered robust for deciding that there is no basis for human hazard concern.

3.2 Available Dose-response Values

To develop dose-response values, this risk assessment uses information from publicly available USEPA documents (such as REDs) and risk assessments to support proposed uses of herbicides for various applications (from the HED) that show the derivation of various PADs and NOAELs for different exposure routes and time frames (short, intermediate, and long term).

Table 3-1 shows the USEPA-derived PADs and NOAELs for each of the five herbicide active ingredients. As shown in Table 3-1, and as previously stated, none of these herbicide active ingredients are considered potential carcinogens. For some of the herbicide active ingredients, the USEPA-derived values were not available for certain exposure routes and time periods. These values were not derived because the herbicide active ingredient had not been found to be toxic through that particular route of exposure.

3.2.1 Aminopyralid

The USEPA (2009a) has developed various dose-response values specific to different toxicological endpoints. Table 3-1 summarizes the dose-response values for aminopyralid.

3.2.1.1 Dose-response Values for Dietary Exposures

Acute dietary PAD - The USEPA has not developed an acute dietary PAD for aminopyralid (USEPA 2009a). A NOAEL of 1,000 mg/kg-day was derived from an acute neurotoxity study in rats based on urine soiling in females and fecal soiling in males at a dose of 2,000 mg/kg-day. Given the high dose necessary to produce toxic effects, there is no concern for acute dietary risk.

Chronic dietary PAD - The USEPA has developed a chronic PAD of 0.5 mg/kg-day for aminopyralid, based on a rat combined chronic toxicity/carcinogenicity study (USEPA 2009a). The PAD is based on a NOAEL of 50 mg/kg. At the LOAEL of 500 mg/kg-day, cecal enlargement, slight mucosal hyperplasia of the cecum in males, and slightly decreased body weights were observed. The RfD was calculated by dividing the NOAEL of 50 mg/kg-day by an uncertainty factor of 100 (10 for interspecies extrapolation, 10 for intraspecies variability). The USEPA recommends that the FQPA SF be reduced to 1 because the overall weight of evidence suggests that aminopyralid does not target the immune system, there is no evidence of developmental toxicity, there is no concern for neurotoxicity, and the dietary and drinking water assessments are based on very conservative assumptions (USEPA 2009a). Therefore, the PAD is equal to the RfD.

3.2.1.2 Dose-response Values for Non-dietary Exposures

Oral NOAELs - The USEPA derived short- and intermediate-term oral NOAELs of 104 mg a.e./kg-day, based on a developmental study in rabbits (USEPA 2009a). At the maternal LOAEL of 260 mg a.e./kg-day, severe inanition and body weight loss, decreased fecal output, and mild incoordinated gait were observed. An uncertainty factor of 100 (10 for interspecies extrapolation, 10 for intraspecies variability) was also developed.

Dermal NOAELs - No dermal absorption studies for aminopyralid are available. However, in a 28-day dermal toxicity study with rabbits, no systemic toxicity occurred at the limit dose of 1,000 mg/kg-day. Therefore, the USEPA (2009a) concluded that aminopyralid is either not absorbed or poorly absorbed through the skin, and that development of dermal NOAELs is not necessary. The USEPA (2009a) also indicated that at 500 mg/kg-day, there was slight inflammation and slight epidural hyperplasia in males, which should be noted on the herbicide label as a potential concern.

Inhalation NOAELs - The same rabbit developmental study used to derive the oral NOAELs was used to develop short- and intermediate-term inhalation NOAELs of 104 mg a.e./kg-day (USEPA 2009a). The route of exposure for the study was oral rather than inhalation, and the USEPA (2009a) assumed absorption to be equivalent to the oral route (i.e., 100% inhalation absorption is assumed). The USEPA (2009a) did not develop a long-term inhalation NOAEL for aminopyralid. In a personal communication (J. Evans, USEPA OPP personal communication, February 28, 2011), the USEPA indicated that for seasonal exposures such as applying herbicides to BLM lands, long-term exposure is not of concern and did not recommend deriving an inhalation NOAEL. An uncertainty factor of 100 (10 for interspecies extrapolation, 10 for intraspecies variability) was also developed.

Target MOE - The target MOE for oral and inhalation exposures for both occupational and residential exposures is 100 (USEPA 2009a). The target MOE is supported by the available data and is based on the standard uncertainty factor of 100 (10 for interspecies extrapolation, 10 for intraspecies variability).

Cancer dose-response value - No evidence of carcinogenicity in mice or rates was identified. Therefore, the USEPA has classified aminopyralid as “not likely to be carcinogenic to humans” in accordance with its *Final Guidelines for Carcinogen Risk Assessment* (USEPA 2005c).

3.2.2 Clopyralid

The USEPA (2009b) has developed various dose-response values specific to different toxicological endpoints. Table 3-1 summarizes the dose-response values for clopyralid.

3.2.2.1 Dose-response Values for Dietary Exposures

Acute dietary PAD - The USEPA (2009b) derived an acute PAD of 0.75 mg/kg-day, based on a maternal NOAEL of 75 mg/kg-day, from a developmental study with rats. At the LOAEL of 250 mg/kg-day, maternal mortality, decreased body weight gains, and reduced food consumption were observed. The selected dose is also protective of developmental effects seen in rabbits at 250 mg/kg-day (NOAEL of 110 mg/kg-day). An uncertainty factor of 100 (10 for interspecies extrapolation, 10 for intraspecies variability) was applied to calculate the RfD (75 mg/kg-day divided by 100). The USEPA recommends that the FQPA SF be reduced to 1 because pre and/or post-natal susceptibility was not observed, because there is a lack of evidence of neurotoxicity, and because exposure estimates are based on conservative, health-protective assumptions (USEPA 2009b). Therefore, the RfD and the PAD are the same.

Chronic dietary PAD – The USEPA has developed a chronic PAD of 0.15 mg/kg-day for clopyralid (USEPA 2009b). The PAD is based on a NOAEL of 15 mg/kg-day based on a rat combined chronic toxicity/carcinogenicity study. At the LOAEL of 150 mg/kg-day, histopathology in the stomach was observed. An uncertainty factor of 100 (10 for interspecies extrapolation, 10 for intraspecies variability) was applied to calculate the RfD (15 mg/kg-day divided by 100). As discussed above, the FQPA SF is set to 1 (USEPA 2009b). Therefore, the RfD and the PAD are the same.

3.2.2.2 Dose-response Values for Non-dietary Exposures

Oral NOAELs - A short-term oral NOAEL of 75 mg/kg-day, and an intermediate oral NOAEL of 15 mg/kg-day were developed using the same study from which the acute PAD was derived (USEPA 2009b). Uncertainty factors of 100 (10 for interspecies extrapolation, 10 for intraspecies variability) were also developed for each duration.

Dermal NOAELs - No dermal absorption studies for clopyralid are available. However, in a 21-day dermal toxicity study with rabbits, no systemic toxicity occurred at the limit dose of 1,000 mg/kg-day. Therefore, the USEPA (2009b) concluded that dermal absorption is low and that potential risks from dermal exposures are not of concern.

Inhalation NOAELs - A short-term inhalation oral NOAEL of 75 mg/kg-day and an intermediate inhalation NOAEL of 15 mg/kg-day were developed using the same study from which the acute PAD was derived (USEPA 2009b). The oral studies were selected because no inhalation studies are available. Absorption is assumed to be equivalent to the oral route (i.e., 100% inhalation absorption is assumed). For both short and intermediate term, the study and endpoint selected are protective of effects observed in all available studies. A long-term inhalation NOAEL was not derived. In a personal communication (J. Evans, USEPA OPP personal communication, February 28, 2011), the USEPA indicated that for seasonal exposures such as applying herbicides to BLM lands, long-term exposure is not of concern and did not recommend deriving an inhalation NOAEL. An uncertainty factor of 100 (10 for interspecies extrapolation, 10 for intraspecies variability) was also developed.

Target MOE - The target MOE for oral and inhalation exposures for both occupational and residential exposures is 100 (USEPA 2009b).

Cancer dose-response value - No evidence of carcinogenicity in mice or rats was identified. Therefore, the USEPA has classified clopyralid as "not likely to be carcinogenic to humans" in accordance with its *Final Guidelines for Carcinogen Risk Assessment* (USEPA 2005c).

3.2.3 2,4-D

Table 3-1 summarizes the dose-response values for 2,4-D.

3.2.3.1 Dose-response Values for Dietary Exposures

Acute dietary PAD - Acute dietary PADs for both the general population and females aged 13-49 years were derived based on a chronic study and a developmental toxicity study with rats (USEPA 2005a). The lower PAD of 0.025 mg/kg-day has been used in this risk assessment. The PAD is based on a NOAEL of 25 mg/kg-day. At the LOAEL of 75 mg/kg-day, skeletal abnormalities were observed. The NOAEL was divided by an uncertainty factor of 1,000 (10 for interspecies extrapolation, 10 for intraspecies variability, 10 for database deficiencies) to derive the RfD (25 mg/kg-day divided by 1,000). The database uncertainty factor was included because a repeat 2-generation reproduction study using the new protocol was lacking. Such a study is required to address concerns for potential endocrine disruption (thyroid and immunotoxicity). The uncertainty factor was added because there was no basis in the current data for removing the default factor. The USEPA (2005a) removed the default FQPA SF of 10 because after applying the traditional uncertainty factors, there were no concerns for the effects seen in developmental toxicity studies. Therefore, the FQPA SF is 1, and the RfD and the PAD are the same.

Chronic dietary PAD - The chronic PAD of 0.005 mg/kg-day was derived from the NOAEL of 5 mg/kg-day in the rat chronic toxicity study. At the LOAEL of 75 mg/kg-day, decreased body weight gain and food consumption in females, and alterations in hematology and clinical parameters in both sexes were observed. An uncertainty factor of 1,000 (10 for interspecies extrapolation, 10 for intraspecies variability, 10 for database deficiencies) was applied to the NOAEL to derive the RfD (5 mg/kg-day divided by 1,000). As discussed above, an FQPA SF of 1 was used, such that the RfD and the PAD are the same.

3.2.3.2 Dose-response Values for Non-dietary Exposures

Oral NOAELs - A short-term oral NOAEL of 25 mg/kg-day was developed using the same study from which the acute PAD was derived. An intermediate-term oral NOAEL of 15 mg/kg-day was developed based on a rat subchronic study. At the LOAEL of 100 mg/kg-day, decreased body weight gain, alterations in some hematology and clinical parameters, and cataract formation were observed.

Dermal NOAELs - A short-term dermal NOAEL of 25 mg/kg-day was developed using the same study from which the acute PAD was derived. An intermediate-term dermal NOAEL of 15 mg/kg-day was developed based on the same study from which the intermediate-term oral NOAEL was derived. A long-term dermal NOAEL of 5 mg/kg-day was developed using the same study from which the chronic PAD was derived. Based on a human dermal absorption study, a dermal absorption factor (DAF) of 10% was derived.

Inhalation NOAELs - A short-term inhalation NOAEL of 25 mg/kg-day was developed using the same study from which the acute PAD was derived. An intermediate-term dermal NOAEL of 15 mg/kg-day was developed based on the same study from which the intermediate-term oral NOAEL was derived. A long-term dermal NOAEL of 5 mg/kg-day was developed using the same study from which the chronic PAD was derived. Absorption via inhalation is assumed to be the same as absorption via the oral route; therefore, the inhalation absorption factor is assumed to be 100%.

Target MOE - The target MOE is 100 for occupational exposures and 1,000 for residential exposures (USEPA 2005a).

Cancer dose-response value – The USEPA has been reviewing the potential carcinogenicity of 2,4-D since 1986 due to concerns for links between 2,4-D exposure and non-Hodgkin's lymphoma. In 1992, the USEPA concluded that "the data are not sufficient to conclude that there is a cause and effect relationship between exposure to 2,4-D and non-Hodgkin's lymphoma." In March 1999, the USEPA classified 2,4-D as "Group D, not classifiable as to human carcinogenicity." Additionally, the USEPA reviewed epidemiological studies in January and December 2004 and concluded that there is no additional evidence that indicate potential carcinogenicity (USEPA 2005a).

3.2.4 Fluroxypyr

Table 3-1 summarizes the dose-response values for fluroxypyr.

3.2.4.1 Dose-response Values for Dietary Exposures

Acute dietary PAD - An acute PAD was not developed (USEPA 2007). No adverse effects were identified following a single dose. No developmental concerns were noted in the database.

Chronic dietary PAD - A chronic PAD of 1 mg/kg-day was developed based on a NOAEL of 100 mg/kg-day in a chronic study with rats (USEPA 2007). Kidney effects were observed at the LOAEL of 500 mg/kg-day. An uncertainty factor of 100 (10 for interspecies extrapolation, 10 for intraspecies variability) was applied to derive the RfD (100 mg/kg-day divided by 100). The FQPA SF was reduced to 1 because the database is considered complete, there are no concerns for pre-and or post-natal toxicity, there was no evidence of neurotoxicity, and the dietary and drinking water studies and residential exposure assessment were conducted using conservative assumptions unlikely to underestimate exposure. Therefore, the RfD and the PAD are the same.

3.2.4.2 Dose-response Values for Non-dietary Exposures

Oral NOAELs - Short-and intermediate-term oral NOAELs of 100 mg/kg-day were derived based on the same study from which the chronic PAD was developed (USEPA 2007).

Dermal NOAELs - Dermal NOAELs were not developed because a 21-day dermal rabbit NOAEL of 1,000 mg/kg-day was identified and there are no developmental or neurological toxicity concerns (USEPA 2007).

Inhalation NOAELs – Short-, intermediate-, and long-term inhalation NOAELs of 100 mg/kg-day were derived based on the same study from which the chronic PAD was developed (USEPA 2007), using route-to-route extrapolation. Absorption is assumed to be equivalent to the oral route (i.e., 100% inhalation absorption is assumed).

Target MOE - The target MOE for oral and inhalation exposures for both occupational and residential exposures is 100 (USEPA 2007).

Cancer dose-response value - Fluroxypyr is classified as “not likely to be carcinogenic to humans” using the USEPA (2005c) carcinogen classification guidelines (USEPA 2007).

3.2.5 Rimsulfuron

Table 3-1 summarizes the dose-response values for rimsulfuron.

3.2.5.1 Dose-response Values for Dietary Exposures

Acute dietary PAD - An acute PAD was not developed (USEPA 2011c). No adverse effects were identified following a single dose in developmental toxicity studies with rats and rabbits.

Chronic dietary PAD - A chronic PAD of 0.118 mg/kg-day was developed based on a NOAEL of 11.8 mg/kg-day from a chronic/carcinogenicity study with rats. The LOAELs of 121 mg/kg-day for males and 568 mg/kg-day for females are based on decreased body weight gain and increased relative liver weights. An uncertainty factor of 100 (10 for interspecies extrapolation, 10 for intraspecies variability) was applied to calculate the RfD (11.8 mg/kg-day divided by 100). The FQPA SF was reduced to 1 because there is no evidence of increased susceptibility following *in utero* or postnatal exposure in developmental studies, there is no evidence of immunotoxicity or neurotoxicity, and the assessments are based on data that will not underestimate potential exposures. Therefore, the RfD and the PAD are the same.

3.2.5.2 Dose-response Values for Non-dietary Exposures

Oral NOAELs - The USEPA (2011c) indicates that there is no appropriate endpoint and that the use pattern does not indicate a need for a risk assessment to address incidental oral exposure.

Dermal NOAELs - The NOAEL identified in a 90-day dog study of 6.25 mg/kg-day was selected to assess short- and intermediate-term dermal exposures (USEPA 2011c). A DAF of 0.17 was derived by the USEPA OPP (J. Evans, USEPA OPP personal communication, March 3, 2012). The USEPA assumed that long-term exposures are not applicable based on label requirements and did not derive a long-term dermal NOAEL.

Inhalation NOAELs - Chronic inhalation toxicity studies for rimsulfuron are not available. Therefore, the NOAEL identified in a 90-day dog study of 6.25 mg/kg-day was selected to assess short- and intermediate-term inhalation exposures (USEPA 2011c). Absorption is assumed to be equivalent to the oral route (i.e., 100% inhalation absorption is assumed). The USEPA assumed that long-term exposures are not applicable based on label requirements and did not derive a long-term inhalation NOAEL.

Target MOE - The target MOE is 100, based on the combined uncertainty factors of 10 for interspecies and 10 for intraspecies variability (USEPA 2011c).

Cancer dose-response value - The USEPA (2011c) indicates that rimsulfuron is considered “not likely to be carcinogenic to humans.”

3.3 Inert (Other) Ingredients

In addition to the active ingredients, most herbicides also contain inert (other) ingredients (i.e., substances included in the formulation that are not the active ingredients) with various functions, such as diluents, binders, dispersants, carriers, stabilizers, neutralizers, antifoamers, and buffers.

Table 3-1
Summary of Toxicological Endpoint Data

Parameter	Aminopyralid	Clopyralid	2,4-D	Fluroxypyr	Rimsulfuron
Acute dietary NOAEL (mg/kg-day)	NA (b)	75	25 (c)	NA (d)	NA (e)
Uncertainty Factor	NA (b)	100	1,000	NA (d)	NA (e)
Food Quality Protection Act Safety Factor (FQPA SF)	NA (b)	1	1	NA (d)	NA (e)
Acute PAD (mg/kg-day) (a)	NA (b)	0.75	0.025	NA (d)	NA (e)
Chronic dietary NOAEL (mg/kg-day)	50	15	5	100	11.8
Uncertainty Factor	100	100	1,000	100	100
Food Quality Protection Act Safety Factor (FQPA SF)	1	1	1	1	1
Chronic PAD (mg/kg-day) (a)	0.5	0.15	0.005	1	0.118
Short-term oral NOAEL (mg/kg-day)	104	75	25	100	NA (f)
Intermediate-term oral NOAEL (mg/kg-day)	104	15	15	100	NA (f)
Short term dermal NOAEL (mg/kg-day)	NA (g)	NA (g)	25 (h)	NA (i)	6.25 (j)
Intermediate term dermal NOAEL (mg/kg-day)	NA (g)	NA (g)	15 (h)	NA (i)	6.25 (j)
Long-term dermal NOAEL (mg/kg-day)	NA (g)	NA (g)	5 (h)	NA (i)	NA (k)
Short term inhalation NOAEL (mg/kg-day)	104 (l)	75 (l)	25 (l)	100 (l)	6.25 (l)
Intermediate term inhalation NOAEL (mg/kg-day)	104 (l)	15 (l)	15 (l)	100 (l)	6.25 (l)
Long-term inhalation NOAEL (mg/kg-day)	NA (m)	NA (m)	5 (l)	100 (l)	NA (k)
Target Margin of Exposure for Oral, Dermal, Inhalation (Residential)	100	100	1,000	100	100
Target Margin of Exposure for Oral, Dermal, Inhalation (Occupational)	100	100	100	100	100
CSF for Oral, Dermal, Inhalation	NA (n)	NA (n)	NA (o)	NA (n)	NA (n)
References	USEPA 2009a	USEPA 2009b	USEPA 2005a,b	USEPA 2007a	USEPA 2011c

-- Not Applicable.
CSF - Cancer Slope Factor.
NA - Not Applicable, according to USEPA risk assessments.
NOAEL - No Observable Adverse Effect Level.
PAD - Population Adjusted Dose.
RfD - Reference Dose.

References:

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Notes:

Short term is defined as up to 30 days, intermediate term is defined as 1 to 6 months, and long term is defined as over 6 months (USEPA 2012).
(a) - The PAD is the NOAEL divided by the uncertainty factor and the FQPA SF. If the FQPA SF is 1, then the PAD equals the Reference Dose (RfD), which is the NOAEL divided by the uncertainty factor.
(b) - A toxic effect attributable to a single dose was not seen in the toxicity database; therefore, an acute endpoint was not identified by USEPA (2009a).
(c) - NOAEL for females aged 13-49 selected, which is lower than the NOAEL of 67 mg/kg-day for the general population.
(d) - USEPA (2007) indicates that no adverse effects were identified following a single oral dose and there are no developmental concerns noted in the database.
(e) - No appropriate endpoint attributable to a single dose available (USEPA 2011c).
(f) - USEPA (2011c) indicates that the use pattern does not indicate a need for risk assessment for this pathway.
(g) - No systemic toxicity seen at the limit dose (1,000 mg/kg-day). Therefore, USEPA determined that dermal risk assessment is not necessary.
(h) - USEPA used route-to-route extrapolation from the oral pathway to derive this NOAEL. Dermal absorption factor assumed to be 10%.
(i) - USEPA (2007) indicates that quantification is not required as 21-day dermal rabbit NOAEL is equal to 1,000 mg/kg-day and there are no developmental or neurological toxicity concerns.
(j) - USEPA used route-to-route extrapolation from the oral pathway to derive this NOAEL. Dermal absorption factor assumed to be 17%.
(k) - USEPA (2011c) assumed that long-term exposures are not expected due to label requirements; therefore, long-term exposure was not evaluated.
(l) - USEPA used route-to-route extrapolation from the oral pathway to derive this NOAEL. Inhalation absorption is assumed to be equivalent to oral absorption.
(m) - Long-term value not provided in USEPA risk assessment. Based on personal communications with USEPA (J. Evans, 2/28/11), for seasonal exposures such as applying herbicides to BLM lands, USEPA would not consider a long term inhalation endpoint since there is no corresponding exposure scenario.
(n) - USEPA risk assessment determined herbicide is classified as "not likely to be carcinogenic to humans".
(o) - USEPA risk assessment determined herbicide is Group D, "not classifiable as to human carcinogenicity".

4.0 EXPOSURE ASSESSMENT

The purpose of the exposure assessment is to predict the magnitude and frequency of potential human exposure to the herbicide active ingredients under consideration in the HHRA. The first step in the exposure assessment process is to identify potential exposure pathways that are appropriate for planned BLM use of the herbicide active ingredients. This step also involves identifying potential receptors (i.e., people who may contact the impacted environmental media of interest) and the exposure routes by which environmental media may be contacted (i.e., ingestion, dermal contact, inhalation). Potential exposure pathways that are judged to be complete are evaluated quantitatively in the risk assessment. According to the USEPA (1989), for an exposure pathway to be complete, the following conditions must exist:

- A source and mechanism of chemical release to the environment;
- An environmental transport medium (for example [e.g.], air, water, soil);
- A point of potential receptor contact with the medium;
- A human exposure route at the contact point (e.g., inhalation, ingestion, dermal contact); and

Where one or more of these conditions is not met, an exposure pathway is not complete.

The second step in the exposure assessment process involves quantifying exposure for each of the receptors and exposure pathways. To estimate the potential risk to human health that may be posed by the planned herbicide use, it is first necessary to estimate the potential exposure dose of each herbicide active ingredient for each receptor. The exposure dose of each herbicide active ingredient is estimated for each receptor via each exposure route/pathway by which the receptor is assumed to be exposed. Exposure dose equations combine the estimates of herbicide active ingredient concentration in the environmental medium of interest, with assumptions regarding the type and magnitude of each receptor's potential exposure to provide a numerical estimate of the exposure dose. The exposure dose is defined as the amount of herbicide active ingredient taken into the receptor, and is expressed in mg/kg-day. The exposure doses are combined with the dose-response values to estimate potential risks for each receptor.

To understand how humans may be exposed to herbicide active ingredients as a result of the BLM vegetation treatment program, it is necessary to understand herbicide use within the BLM vegetation treatment program. Public lands are classified in terms of land programs. Within each land program, aerial-, ground-, or boat-based applications may be used. Various application vehicles (airplane, helicopter, all-terrain vehicle (ATV), utility vehicle (UTV), boat, horse, or human) can be used, and for each vehicle, there are different application methods, including deposition (from an airplane or helicopter), boom/broadcast, and spot applications. Similarly, there are different BLM job descriptions associated with each application method. It is assumed that occupational receptors may be incidentally exposed to herbicide active ingredients through dermal contact and inhalation exposure pathways. These potential exposures are evaluated for each herbicide active ingredient under routine use, assuming that use is consistent with label directions. Reference herbicide labels are provided in Appendix A; additional manufacturers may formulate the herbicide active ingredients into herbicides under different trade names. In addition, an accidental spill scenario, assuming an herbicide active ingredient spill to worker skin, is evaluated for the occupational receptors. The BLM vegetation treatment program is discussed in Section 4.1. The potential occupational receptors and exposure scenarios are discussed in Section 4.2.

Members of the public may also be incidentally exposed to herbicide active ingredients. Such receptors may include hikers, hunters, berry pickers, swimmers, anglers, area residents, and Native Americans using natural resources on public lands. Exposures to both spray drift and direct spray/accidental spill scenarios are evaluated. The potential public receptors are discussed in Section 4.3.

The methods used to estimate concentrations of herbicide active ingredients to which occupational and public receptors could be exposed are discussed in Section 4.4.

4.1 Overview of the BLM Vegetation Treatment Program

This section identifies the land programs, application types, application vehicles, and application methods for herbicide use in the BLM vegetation treatment program.

4.1.1 Land Programs

The BLM vegetation treatment program covers six land types or programs:

- Rangeland
- Public-domain Forestland
- Energy and Mineral Sites
- Rights-of-way
- Recreation and Cultural Sites
- Aquatic Sites

Herbicides are used in rangeland improvement and silvicultural practice to improve the potential for success of desired vegetation by reducing competition for light, moisture, and soil nutrients with less desirable plant species. Herbicides are used to manage or restrict noxious plant species and to suppress vegetation that interferes with man-made structures or transportation corridors.

Herbicides are a component of the BLM's integrated weed management program, and are used in varying degrees in all land treatment categories. Herbicide use under the six land programs is discussed below. Table 4-1 presents the herbicide use proposed for each land program.

4.1.1.1 Rangeland

Rangeland vegetation treatment operations provide forage for domestic livestock and wildlife by removing undesirable competing plant species and preparing seedbeds for desirable plants. Approximately 89% of the herbicide treated acreage in the BLM vegetation treatment program falls in the rangeland improvement category.

Of the five herbicide active ingredients being evaluated, all are proposed for use in rangeland situations. Proposed application methods include airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications). Application vehicles and methods are discussed further in Section 4.1.2.

4.1.1.2 Public-domain Forestland

Public-domain forestland vegetation treatment operations, designed to ensure the establishment and healthy growth of timber crop species, are one of the BLM's least extensive programs for herbicide treatment. These operations include site preparation, plantation, maintenance, conifer release, pre-commercial thinning, and non-commercial tree removal. Site preparation treatments prepare newly harvested or inadequately stocked areas for planting new tree crops. Herbicides used in site preparation reduce vegetation that competes with conifers. In the brown-and-burn method of site preparation, herbicides are used to dry the vegetation, to be burned several months later. Herbicides are used in plantations some time after planting to promote the dominance and growth of already established conifers (release). Pre-commercial thinning reduces competition among conifers, thereby improving the growth rate of desirable crop trees. Non-commercial tree removal is used to eliminate dwarf mistletoe infested host trees. These latter two silvicultural practices primarily use manual applications methods (described in Section 4.1.2). Herbicide uses in public-domain forests constitute less than 4% of the vegetation treatment operations in the BLM program.

Of the five herbicide active ingredients being evaluated, all are proposed for use on public-domain forestland. Proposed application methods include airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications). Application vehicles and methods are discussed further in Section 4.1.2.

4.1.1.3 Energy and Mineral Sites

Vegetation treatments in energy and mineral sites include the preparation and regular maintenance of areas for use as fire control lines or fuel breaks, and the reduction of plant species that could pose a hazard to fire control operations. More than 50% of the vegetation treatment programs at energy and mineral sites are herbicide applications.

Of the five herbicide active ingredients being evaluated, all are proposed for use on energy and mineral sites. Proposed application methods include airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications). Application vehicles and methods are discussed further in Section 4.1.2.

4.1.1.4 Rights-of-way

Right-of-way treatments include roadside maintenance and maintenance of power transmission lines, waterways, and railroad corridors. In roadside maintenance, vegetation in ditches and on road shoulders is removed or reduced to prevent brush encroachment into driving lanes, to maintain visibility on curves for the safety of vehicle operators, to permit drainage structures to function as intended, and to facilitate maintenance operations. Herbicides have been used in nearly 50% of the BLM's roadside vegetation maintenance programs.

Of the five herbicide active ingredients being evaluated, all are proposed for use on right-of-way sites. Proposed application methods include airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications). Application vehicles and methods are discussed further in Section 4.1.2.

4.1.1.5 Recreation and Cultural Sites

Recreation and cultural site maintenance operations provide for the safe and efficient use of BLM facilities and recreation sites and for permittee/grantee uses of public amenities, such as, ski runs, waterways, and utility terminals. Vegetation treatments are made for the general maintenance and visual appearance of the areas and to reduce potential threats to the site's plants and wildlife, as well as to the health and welfare of visitors. The site maintenance program includes the noxious weed and poisonous plant program. Vegetation treatments in these areas are also done for fire management purposes. The BLM uses herbicides on approximately one-third of the total recreation site acreage identified as needing regular treatment operations.

Of the five herbicide active ingredients being evaluated, all are proposed for use on recreation and cultural sites. Proposed application methods include airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications). Application vehicles and methods are discussed further in Section 4.1.2.

4.1.1.6 Aquatic Sites

Aquatic vegetation management involves controlling the vegetation in a variety of settings ranging from rivers, streams, and canals to ponds, lakes, and water holdings. Management of aquatic vegetation addresses sites at which the flow of water has been altered, native/desirable vegetation has been displaced, and/or recreational activities have been reduced. This HHRA includes exposure scenarios in which public receptors may contact herbicides from either spray drift, accidental spray or spills, or treatment of a water body. The potential exposure scenarios include swimming, drinking water, and fish ingestion. The water body selected for evaluation in the HHRA is a pond ¼ acre in area and 1 m deep (3.28 feet), which is the pond size assumed by the BLM in the 17-States PEIS (USDOI BLM 2007a). While other water bodies, including streams, rivers, and various size ponds or lakes, may also be encountered, the pond was selected as a representative water body to provide a conservative estimate of potential exposure.

2,4-D is currently used on aquatic sites. As indicated in Table 4-1, there are three categories of aquatic application of 2,4-D, which are based on the type of vegetation to be treated. For the treatment of floating and emerged vegetation or the treatment of submerged vegetation in a volume of water, proposed application methods include airplane, helicopter, boat (boom/broadcast or spot applications), truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications). For the treatment of submerged vegetation on a water body bottom, only boat applications (boom/broadcast or spot applications) are applicable. Application vehicles and methods are discussed further in Section 4.1.2.

4.1.2 Application Methods

The BLM conducts pretreatment surveys in accordance with BLM Handbook H-9011-1 (*Chemical Pest Control*) before making a decision to use herbicides on a specific land area. The herbicides can be applied by via airplane, helicopter, boat (boom/broadcast or spot applications), truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications) with the selected technique dependent upon the following variables:

- Treatment objective (removal or reduction)
- Accessibility, topography, and size of the treatment area
- Characteristics of the target species and the desired vegetation
- Location of sensitive areas in the immediate vicinity (potential environmental impacts)
- Anticipated costs and equipment limitations
- Meteorological and vegetative conditions of the treatment area at the time of treatment

Herbicide applications are scheduled and designed such that potential impacts to non-target plants and animals are minimized, while the objectives of the vegetation treatment program are kept consistent. Herbicides are applied from either the air or ground. The herbicide formulations may be in a liquid or granular form, depending on resources and program objectives. Aerial methods employ boom-mounted nozzles for liquid formulations or rotary broadcasters for granular formulations, carried by helicopters or airplanes. Ground application methods include vehicle- and boat-mounted, backpack, and horseback application techniques. Vehicle- and boat-mounted application systems use fixed-boom or hand-held spray nozzles mounted on trucks or ATVs/UTVs. Backpack systems use a pressurized sprayer to apply an herbicide as a broadcast spray directly to one or a group of individual plants.

4.1.2.1 Aerial Application Methods

Aerial application can be conducted by airplane (fixed-wing aircraft) or helicopter (rotary-wing aircraft). Between 2006 and 2011, the BLM treated 73% of its herbicide treatment sites by air. Helicopters are preferred on rangeland projects because the treatment units are numerous, far apart, and often small and irregularly shaped.

The size and type of these aircraft may vary, but the equipment used to apply the herbicides must meet specific guidelines. Contractor-operated helicopters or fixed-wing aircraft are equipped with an herbicide tank or bin (depending on whether the herbicide is a liquid or granular formulation). For aerial spraying, the aircraft is equipped with cylindrical jet-producing nozzles no less than 1/8 inch in diameter. The nozzles are directed with the slipstream, at a maximum of 45 degrees downward for fixed-wing applications, or up to 75 degrees downward for helicopter applications, depending on the flight speed. Nozzle size and pressure are designed to produce droplets with a diameter of 200 to 400 microns. For fixed-wing aircraft, the spray boom is typically ¾ of the wingspan, and for helicopters, the spray boom is often ¾ of the rotor diameter. All spray systems must have a positive liquid shut-off device that ensures that no herbicide continues to drip from the boom once the pilot has completed a swath (i.e., specific spray path). The nozzles are spaced to produce a uniform pattern for the length of the boom.

Using helicopters for herbicide application is often more expensive than using fixed-wing aircraft, but helicopters offer greater versatility. Helicopters are well adapted to areas dominated by irregular terrain and long, narrow, and irregularly shaped land patterns, a common characteristic of public lands. Various helicopter aircraft types are used, including, Bell, Sikorsky, and Hiller models. These helicopters must be capable of accommodating the spray equipment and the herbicide tank or bin, and of maintaining an air speed of 40 to 50 miles per hour at a height of 30 to 45 feet above the vegetation (depending upon the desired application rate), and they must meet BLM safety performance standards.

Fixed-wing aircraft include the typical, small “cropduster” type aircraft. Fixed-wing aircraft are best suited for smoother terrain and larger tracts of land where abrupt turning is not required. Because the fixed-wing aircraft spraying operations are used for treating larger land areas, the cost per acre is generally lower than that of helicopter spraying. Aircraft capability requirements for fixed-wing aircraft are similar to helicopter requirements, except that an air speed of 100 to 120 miles per hour is necessary, with spraying heights of 10 to 40 feet generally used to produce the desired application rates.

Batch trucks are an integral part of any aerial application operation. They serve as mixing tanks for preparing the correct proportions of herbicide and carrier, and they move with the operation when different landing areas are required.

The number of workers involved in a typical aerial spray project varies according to the type of activity. A small operation may require up to six individuals, while a complex operation may require as many as 20 to 35 workers. An aerial operations crew for range management, noxious weed management, and right-of-way maintenance usually consists of five to eight individuals. Typically, personnel on a large project include a pilot, a mixer/loader, who is responsible for mixing the herbicide and loading it to the tank, a contracting officer’s representative, an observer-inspector, a one- to six-member flagging crew, one or two law enforcement officers, one or two water monitors, and one or two laborers. Optional personnel include an air operations officer, a radio technician, a weather monitor, and a recorder. Workers evaluated in the HHRA for aerial applications include a pilot and a mixer/loader, as these are the receptors most likely to be exposed to herbicides. Other personnel are expected to have less or similar herbicide exposure.

4.1.2.2 Ground Application Methods

There are two types of ground application methods: human application methods (backpack and horseback) and vehicle application, which includes ATV/UTV-based application methods (spot-treatment or boom/broadcast treatment), and truck-mounted application methods (spot-treatment or boom/broadcast treatment). These are described in greater detail below.

Human Application Methods - Humans may apply herbicides by backpack or on horseback. The backpack method requires the use of a backpack spray tank for carrying the herbicide, with a handgun applicator with a single nozzle for herbicide application. Backpack and horseback spraying techniques are best adapted for very small scale applications in isolated spots and areas not accessible by vehicle. These methods are primarily used for spot treatments around signposts, spraying competing trees in public-domain forestland, delineators, power poles, scattered noxious weeds, and other areas that require selective spraying.

Backpack treatment is the predominant ground-based method for silviculture and range management. The principle hand application techniques are injection and stump treatment. Injection involves applying an herbicide with a hand-held container or injector through slits cut into the stems of target plants. Individual stem treatment by the injection method is also used for thinning crop trees or removing the undesirable trees. Stump treatment entails applying liquid herbicide directly to the cut stump of the target plant to inhibit sprouting. An herbicide can be applied by dabbing or painting the exposed cambium of a stump, or by using a squeeze bottle on a freshly cut cambium surface. Along with liquid formulations, certain active ingredients are formulated in a granular form that allows for direct application to the soil surface. Pressurized backpack treatment operations typically involve a supervisor (who may also function as a mixer/loader), an inspector, a monitor, and 2 to 12 crewmembers. The receptor evaluated in this risk assessment for both backpack and horseback treatments is a combined applicator/mixer/loader, because these treatments are small in scale and it is likely that the same worker would mix the herbicide as well as load and apply the herbicide.

Vehicle Application Methods - Ground-based herbicide spray treatments involve use of a truck or an ATV/UTV. A vehicle application is made using a boom with several spray nozzles (boom/broadcast treatment) or a handgun with a single nozzle (spot treatment). Ground vehicle spray equipment can be mounted on ATVs/UTVs or trucks. Because of their small size and agility, the ATVs/UTVs can be adapted to many different situations.

The boom spray equipment used for vehicle operations is designed to spray wide strips of land where the vegetation does not normally exceed 18 inches in height and the terrain is generally smooth and free of deep gullies. Ground spraying from vehicles occurs along highway rights-of-way, energy and mineral sites, public-domain forestlands, and rangeland sites.

Spot-gun spraying is best adapted for spraying small, scattered plots. It may also be used to spray signposts and delineators within highway rights-of-way, and around wooden power lines as a means of reducing fire hazards within power line rights-of-way. This technique is also used to treat scattered noxious weeds, but it is limited to areas that are accessible by vehicles.

Right-of-way maintenance projects frequently use vehicle-mounted application techniques. A truck with a mixing/holding tank uses a front-mounted spray boom or a hand-held pressurized nozzle to treat roadside vegetation on varying slopes. However, using this equipment for off-road right-of-way projects is limited to gentle slopes (less than 20%) and open terrain. Workers typically involved include a driver/mixer/loader and an applicator. Therefore, receptors evaluated in this HHRA include an applicator, a mixer/loader, and a combined applicator/mixer/loader. The applicator receptor is evaluated both separately and combined with the mixer/loader receptor to cover both smaller scale operations conducted by one person as well as larger scale operations where more workers are involved.

4.1.2.3 Aquatic Application Methods

Of the five herbicides addressed in this risk assessment, only 2,4-D is used in aquatic environments.

Aquatic vegetation, at moderate growth levels, is useful because it produces oxygen, food, and cover for fish and other aquatic organisms. However, in overabundance, aquatic plants can become weedy, crowd out desirable plants, adversely affect other aquatic life, and interfere with human uses of water.

Aquatic Application Techniques - Four zones in a body of water may be treated to manage aquatic weeds: the water surface, the total water volume, the bottom 1 to 3 feet of water, and the bottom sediment surface, as described below:

- Water surface. Generally, only 1/4 to 1/3 of the surface area should be treated at a time. Applications are made to floating or emerged weeds, with the spray mixture being applied directly to the plants.
- Total Water Volume: The whole body of water is treated when working in this particular zone. Treatments are usually made to 1/4 to 1/3 of the total water volume at a time. Applications can be made by metering or injecting the herbicide into the water from booms trailing behind the boat or as a spray over the water surface. Applications of this type are made to submerged aquatic plants and algae.
- Bottom Water Zone: Treating the deepest 1 to 3 feet of water is the principle behind making applications in the bottom-layer zone. Such treatments are generally made by attaching several flexible hoses at specific intervals on a rigid boom. Each hose is equipped with a nozzle and may be weighted to reach the depth desired. The length of hose and the speed of the boat carrying the application equipment also affect the depth of application. Such applications are beneficial because they apply the herbicide in a layer nearer the area where the herbicide can be taken up by the weedy species.

- Bottom Sediment Surface: The final zone refers to applications made to the bottom sediment of a drained pond, lake or channel.

Aquatic Application Equipment - To treat small areas, a compressed-air sprayer with a hand-operated pump may be all that is needed. Higher-quality compressed-air sprayers with carbon dioxide gas for constant pressure are available but are more expensive. For larger areas, a boat-mounted pump-and-tank rig with one line may be used to treat emerged plants on a spot treatment basis. A boom attached to the boat may be used when broadcast applications are made to the surface of the water. Booms with flexible hoses attached to the boom may be used to make the application below the water surface. It is also assumed that herbicides may be applied using aerial methods. The standard ground-based application methods may also be used.

Applications of granules and slow-release pellets can be made either using a cyclone spreader or by hand. The granules sink to the bottom, where the chemical is slowly released in the relatively small volume of water where the new shoots are beginning to grow.

Vegetation Management - Static Water - Static water is water in ponds, lakes, or reservoirs that has little or no inflow and outflow. Floating and emerged vegetation is managed by direct applications of the spray mixture to foliage by aircraft, with ground equipment operated from the bank if the pond is small or if the weeds occur only around the margins, or from a boat using various types of booms or hand applicators.

Submerged vegetation and algae can be managed with spray or granular applications. Spray applications can be made by aircraft, boat, or ground equipment. Applications can be made under the water surface by injection through a hose pulled behind a boat, or by a series of hoses attached to a boom that is attached to the boat. Granular herbicides may be broadcast by hand or manual spreaders over small areas. Special granule spreaders mounted on aircraft or boats are used for large-scale applications.

Vegetation Management - Flowing Water - Aquatic vegetation in flowing water is difficult to manage. Floating and emerged vegetation in flowing water are treated using the same methods as floating and emerged vegetation in static water. Submerged vegetation and algae can be controlled effectively in flowing water only by continuously applying enough herbicide at a given spot to maintain the needed concentration and contact time.

The applicator receptor will be evaluated both separately and combined with the mixer/loader receptor to cover both smaller scale operations conducted by one person as well as larger scale operations where more workers are involved.

4.1.3 Herbicide Use Parameters

Herbicide application rates are dependent on the target species, the presence and condition of non-target vegetation, the soil type, the depth to the water table, and the presence of other water sources. Table 4-1 summarizes the applications and use for each of the herbicide active ingredients. Both typical and maximum application rates are provided for each application scenario, vehicle, and method in each land program. As shown in the table, and as discussed above, not all herbicide active ingredients are used for all potential application scenarios. 2,4-D is used in the BLM treatment program under multiple scenarios, and its use is difficult to generalize. Therefore, the use table presents five sets of application rates for 2,4-D, in terms of acid equivalents, for the following application scenarios:

- Terrestrial use for annual and perennial species. May be applied aerially or using any of the standard ground application methods (typical and maximum application rates of 1 and 2 lbs a.e./acre, respectively).

- Terrestrial use for woody species. May be applied aerially or using any of the standard ground application methods. For certain woody species, higher application rates may be used, according to product labels. Treatment of woody species with 2,4-D represents a minor use by the BLM, but in order to provide a full range of risk estimates this use has been included in the risk assessment (typical and maximum application rates of 2 and 4 lbs a.e./acre, respectively).

- Aquatic use for treatment of floating and emerged vegetation. May be applied aerially, by any of the standard ground application methods, or by boat, using spot or boom/broadcast application methods (typical and maximum application rates of 2 and 4 lbs a.e./acre, respectively).

- Aquatic use for treatment of a volume of water to control submerged vegetation. May be applied aerially, using any of the standard ground application methods, or by boat, using spot or boom/broadcast application methods (typical and maximum application rates of 5.4 and 10.8 lbs a.e./acre-foot, respectively).

- Aquatic use for treatment of water body bottom. These treatments are conducted using a granular formulation of 2,4-D with a heat-treated attaclay granule carrier that allows the granule to drop to the bottom of the pond following application. Application is conducted by boat, using spot or boom/broadcast application methods (typical and maximum application rates of 19 and 38 lbs a.e./acre, respectively).

4.2 Occupational Receptors

An exposure scenario is defined by a receptor and the exposure pathways by which that receptor may come into contact with herbicide active ingredients used in the BLM vegetation treatment program. Both routine-use and accidental exposure scenarios are included in the occupational evaluation.

4.2.1 Routine-use Exposure Scenarios

For aerial applications, occupational receptors that may come into contact with herbicide active ingredients include:

- Pilot
- Mixer/Loader

For ground applications by backpack and horseback, which are generally very small in scale, the occupational receptor is assumed to be:

- Applicator/Mixer/Loader

For aquatic applications of granular product by boat, available exposure data suggest that the majority of the exposure occurs during mixing and loading. Therefore, the occupational receptor is assumed to be:

- Applicator/Mixer/Loader

For the remaining application methods (spot and boom/broadcast methods for ATV/UTV, truck mount, and boat applications of liquid products), the herbicide treatment job could be large enough to support a crew, in which case the applicator might be a different person than the mixer/loader. Alternatively, the job could be small enough that the applicator and the mixer/loader would be the same person. Therefore, the following occupational receptors are evaluated:

- Applicator
- Mixer/Loader
- Applicator/Mixer/Loader

Table 4-2 summarizes the application types, vehicles, and methods; identifies the occupational receptors and potential exposure pathways evaluated; and provides exposure assumptions for the occupational receptors. These exposure assumptions were derived using information from the BLM about the proposed use of herbicides, as well as unit exposure (UE) information from the *Occupational Pesticide Handler Unit Exposure Surrogate Reference Guide*

(USEPA 2012b). The reference guide provides empirical dermal and inhalation exposure data for workers mixing, loading, or applying pesticides (USEPA 2012b). The reference guide replaces the older Pesticide Handlers Exposure Database (PHED; USEPA 1998b). However, the newer reference guide does not provide unit exposures appropriate for the spot application scenarios evaluated in this HHRA. Therefore, the USEPA recommends that the PHED values for rights-of-way be used to evaluate spot applications (J. Evans, USEPA OPP personal communication, March 20, 2012).

Generally, UEs are expressed in units of mg/lb a.i. and equate the milligrams of active ingredient absorbed by an occupational receptor to the pounds of active ingredient handled in a given day or exposure scenario. The UEs pertain to application rates in units of a.e. or a.i. (J. Evans, USEPA OPP personal communication, July 12, 2012), with no adjustment necessary. Table 4-3 lists the UEs used in this risk assessment. For the dermal exposure pathway, two sets of UEs are listed, one of which assumes that worker personal protective equipment (PPE) requires gloves, and one of which assumes that gloves are not required. It has been assumed that per BLM policy, all workers, with the exception of pilots, are required to wear gloves. The dermal UE for pilots provided in USEPA (2012b) is based on an enclosed cockpit and no gloves, and is the selected value for this HHRA. The dermal UE assumes gloves are worn and has been used for the remaining receptors. The UEs for the various exposure scenarios are assigned to each occupational receptor in Table 4-2.

The majority of the herbicide active ingredients evaluated in this HHRA are present in liquid formulations. Rimsulfuron may be present either as a dry flowable or water-soluble granule. Therefore, the UEs for mixing/loading of dry flowables is applicable for rimsulfuron (J. Evans, USEPA OPP personal communication, 8/24/2011). The UEs for this scenario are listed in Table 4-3.

One form of 2,4-D is present in a heat-activated attaclay granule, and is applied via boat only. UEs for mixing and loading granules are used to evaluate this form of 2,4-D. UEs are not available for the application of granules as the majority of the exposure would be during mixing/loading. Furthermore, it is likely that the person doing the mixing and loading would also be applying the herbicide. Therefore, the UEs for the mixing/loading scenario are applied to the combined applicator/mixer/loader scenario (J. Evans, USEPA OPP personal communication, August 24, 2011).

Workers are assumed to weigh 79.5 kilograms (kg; 175 lbs) in accordance with USEPA (2012a). Estimates of the number of hours per day a worker may be engaged in applying herbicides, the number of days per year the worker applies herbicides, and the years of potential exposure were provided by the BLM. The BLM also provided data regarding the number of acres treated per hour. Note that the number of days per year and the years of exposure are not used in the calculations for noncarcinogenic effects and are therefore provided for informational purposes only. The NOAELs for short-, intermediate-, and long-term exposure account for the length of time the worker is potentially exposed. As noted previously, the USEPA noted (J. Evans, USEPA OPP personal communication, February 28, 2011) that long-term exposure is not of concern for seasonal exposures such as those associated with BLM herbicide applications. However, where long-term NOAELs are available, long-term exposures estimates are derived.

4.2.2 Accidental Exposure Scenarios

Accidental exposures for occupational receptors could occur via spills, breakage of application equipment hoses, or direct spray onto a worker. As a worst-case scenario for accidental exposure, a direct spill to an occupational receptor is evaluated. The spill scenario evaluated by the BLM in the 17-States PEIS (USDOI BLM 2007a) assumes that 0.5 L of the formulation is spilled on a worker receptor. It is assumed that the 80% of the spill lands on clothing and 20% lands on bare skin. The penetration rate through clothing is assumed to be 30%.

4.3 Public Receptors

Public lands administered by the BLM are diverse, and include rangeland, public-domain forestland, energy and mineral sites, rights-of-way, and recreation and cultural sites. Lakes, ponds, and waterways may also be present on these lands. Public land is used by the public for a variety of occupational, recreational, and cultural activities.

Hunters and hikers, as well as anglers and swimmers, enjoy these public lands. Harvesting of natural resources by the public, including berry picking, harvesting of fish for consumption, and the gathering of materials for Native American crafts such as basket weaving, occurs on public lands.

When herbicides are used as part of a vegetation treatment program on public lands, the BLM takes care to flag the area to be treated and to post the area with warnings about when re-entry can occur safely.

This HHRA evaluates the potential risk to public receptors who use public lands treated with herbicides. The HHRA develops exposure scenarios that combine potential receptors and exposure pathways to identify potential worst-case exposures to the herbicide active ingredients addressed in this HHRA. Two types of public use exposure scenarios are addressed:

- During routine use of public lands, potential exposure to herbicide active ingredients that may have drifted outside of the area of application.
- Accidental scenarios in which public receptors prematurely enter a sprayed area, are sprayed directly, or contact water bodies that have accidentally been sprayed directly or into which an herbicide active ingredient has accidentally been spilled.

Although all of these exposure scenarios are expected to occur only rarely, they are nonetheless used as the basis for evaluating potential public health risks associated with herbicide use in the BLM vegetation treatment program.

Based on consideration of potential public uses of BLM lands, and consistent with the 17-States PEIS (USDOI BLM 2007a; see Section 5), receptors evaluated in this HHRA include the following:

- Hiker/Hunter - adult
- Berry Picker – young child (aged 0 to 6) and adult
- Angler - adult
- Swimmer – young child (aged 0 to 6) and adult
- Nearby Resident – young child (aged 0 to 6) and adult
- Native American – young child (aged 0 to 6) and adult

Although many different exposure scenarios and receptors could be evaluated, the selected receptors cover a range of potential exposures that could occur under worst-case conditions on public lands. As shown in Table 4-4, it is assumed that these receptors could be exposed through one or more of the following exposure pathways:

- Dermal contact with spray (hiker/hunter, berry picker, angler, nearby resident, and Native American)
- Dermal contact with foliage (hiker/hunter, berry picker, angler, nearby resident (lawn), and Native American)
- Dermal contact with water while swimming (swimmer and Native American)
- Occasional ingestion of drinking water (hiker/hunter, berry picker, angler, and Native American)
- Incidental ingestion of water while swimming (swimmer; note that while the Native American is assumed to swim, incidental ingestion of water during swimming is not evaluated since the Native American is also assumed to drink from the pond, which would include any incidental ingestion during swimming)

- Ingestion of berries (berry picker, nearby resident, and Native American)
- Ingestion of fish (angler and Native American)

The child receptors evaluated are assumed to range in age 0 to 6 years. A child receptor was not included with the evaluation of the hiker/hunter scenario or the angler scenario. The evaluation of the berry picker child includes all the exposure scenarios assumed for the hiker/hunter (dermal contact with spray, dermal contact with herbicide, and occasional ingestion of drinking water, plus ingestion of berries). A separate child receptor is not necessary for evaluating a child aged 0 to 6 who may participate in hiking and hunting, as the potential risks would be equal to the berry picker child risks, less the berry ingestion risks. Therefore, the evaluation of the berry picker child is sufficiently protective of young children who hunt and/or hike. Fish ingestion is not expected to be a significant pathway for young children (aged 0 to 6). Based on statistics presented in Table 10-1 of USEPA (2011a), less than 20% of children 6 and under consume fish, with a 95th percentile consumption rate less than 6 grams per kilogram per day (g/kg-day, 90 grams per day [g/day] assuming a 15 kg [33 lbs] body weight). Fish ingestion is assumed for the Native American child receptor, at a much higher ingestion rate (167 g/day) and is therefore protective of any young children who may ingest fish caught from a treated pond.

Although all public receptor exposures to herbicide active ingredients used on public lands are considered to be accidental, public receptor exposures are evaluated under two scenarios. Routine-use exposures are assumed to occur when public receptors come into contact with environmental media that have been impacted by spray drift. As discussed in Section 3.0, dose-response values are available for short, intermediate, and long-term exposures. While it is possible that public receptors use public lands under intermediate and long-term time frames, it is unlikely that public receptors would be exposed to herbicides under the routine-use scenario for more than a short-term exposure, which is defined as up to 30 days (USEPA 2012a). Therefore, short-term dose-response values are used to evaluate the public receptors under the routine-use exposure scenario. Even this scenario may be unlikely, as the short-term NOAELs have been derived based on animal studies where the animals are repeatedly exposed to the herbicide on a daily basis, while the public receptors are assumed to contact herbicides only rarely. To account for the unlikely possibility that public receptors could repeatedly enter areas that have been recently sprayed, the Uncertainty Analysis includes an evaluation of potential risks to public receptors under intermediate and long-term exposure scenarios (Section 5.4). Accidental exposures are assumed to occur when public receptors come into contact with environmental media that have been subject to direct spray or spills. Table 4-4 shows the receptors and exposure pathways evaluated for each herbicide active ingredient. Each of these scenarios is discussed below.

4.3.1 Routine-use Exposure Scenarios

Signage is used to identify areas that are directly sprayed under the BLM vegetation treatment program and to warn against re-entry. It is assumed that under routine conditions, these warnings are heeded. Therefore, public exposures under routine-use scenarios are assumed to occur “off-site,” where “on-site” is the area that has been directly sprayed.

Although all precautions are taken to limit the amount of spray drift from an herbicide application, spray drift can result in deposition of herbicide on areas outside of the directly sprayed area. Spray drift is associated with larger spraying efforts, such as aerial or boom/broadcast applications. It is assumed that a public receptor could walk through vegetated areas upon which spray drift has settled. If the spray drift deposits in areas where wild berries occur, a public receptor could ingest those berries. Spray drift could also settle on bodies of water, which could be contacted by a public receptor while swimming or ingested by drinking. Fish could also be ingested from spray drift-impacted bodies of water. Because spray drift could potentially affect several environmental media, the exposure scenarios developed for each receptor have assumed exposure to multiple environmental media.

The Native American scenario was developed based on recommendations by the USEPA (J. Evans, USEPA OPP personal communication, 2003). The specific receptor is a Native American basket weaver involved in gathering plant materials and other activities related to weaving baskets. The USEPA suggests evaluating the dermal contact with foliage exposure pathway. In its memorandum, the USEPA states:

> "It is expected that the oral intake of herbicides will be minimal by comparison to the above dermal exposure pathway. That is because basket weavers tend to "spit-off" plant residues (due to aftertaste) when mouth stripping plant materials (M. Dong, California Department of Pesticide Regulations, personal communication)."

For completeness, in addition to the dermal contact pathway recommended by the USEPA (J. Evans, USEPA OPP personal communication, 2003), the Native American (adult and child) is also assumed to be exposed through direct contact with spray drift, berry ingestion, dermal contact while swimming, ingestion of water for drinking, and fish ingestion.

The routine-use exposure scenarios are described in greater detail below.

4.3.1.1 Spray Drift and Runoff

Spray Drift on Receptors - In this scenario it is assumed that a receptor is exposed to an herbicide active ingredient that has drifted outside the spray area. Spray drift contact is evaluated for the following receptors:

- Adult Receptor - hiker/hunter, berry picker, angler, nearby resident, and Native American
- Child Receptor - berry picker, nearby resident, and Native American

Contact with Spray Drift on Vegetation - Contact with vegetation that has received off-target spray drift may result in dermal exposure by hikers, berry pickers, anglers, and nearby residents (on lawn). In addition, berry pickers may ingest fruit on which spray drift has settled. This scenario is also evaluated for the aquatic use of 2,4-D, assuming off-target spray drift onto terrestrial vegetation.

Dermal contact with spray drift settled on vegetation is evaluated for:

- Adult Receptor - hiker/hunter, berry picker, angler, nearby resident (lawn), and Native American
- Child Receptor - berry picker, nearby resident (lawn), and Native American

Ingestion of spray drift settled on berries is evaluated for:

- Adult Receptor - berry picker and Native American
- Child Receptor - berry picker and Native American

Spray Drift onto Water Body/Runoff into Water Body - Spray drift could settle onto water bodies during applications of terrestrial herbicide active ingredients, as well during aquatic 2,4-D applications by aerial or ground boom methods. It is assumed that spray drift is not possible for aquatic 2,4-D applications by boat to a water body bottom for treatment of submerged vegetation. For aquatic herbicides, the spray drift scenario assumes that the active ingredient settles onto an adjacent pond that was not targeted for spraying. Terrestrial herbicides are also assumed to contribute to pond concentrations via overland runoff. Incidental ingestion and dermal contact with water while swimming is evaluated for:

- Adult Receptor - swimmer
- Child Receptor - swimmer

In addition, the Native American child and adult receptors are evaluated for dermal contact while swimming and ingesting drinking water. While incidental ingestion of water could occur while swimming, incidental ingestion was not evaluated separately because it results in minimal exposure, as compared to drinking water exposure.

An angler could fish in and ingest fish from a water body that has received spray drift. Therefore, fish ingestion is evaluated for:

- Adult Receptor - angler and Native American
- Child Receptor - Native American

In addition, hikers, berry pickers, anglers, and Native American receptors could get part of their day's drinking water from a water body that has received spray drift. Occasional drinking water ingestion is evaluated for:

- Adult Receptor - hiker/hunter, berry picker, angler, and Native American
- Child Receptor - berry picker and Native American

4.3.2 Accidental Exposure Scenarios

In addition to exposures due to inadvertent spray drift, this HHRA also evaluates potential acute accidental exposures by public receptors to the herbicide active ingredients. Accidental exposure could occur through direct spray and spills. The same types of receptors introduced above are also evaluated for the accidental scenarios. However, because direct spray or spills are localized, exposures to multiple media are not assumed in these scenarios. Table 4-4 shows the receptors, exposure pathways, and herbicide active ingredients that are evaluated for each of the exposure scenarios. It is assumed that each of the herbicide active ingredients could be directly sprayed onto humans, foliage, and berries, and that each of the herbicide active ingredients could be directly sprayed or spilled into a water body. For the aquatic use of 2,4-D, the direct spray pathway is a re-entry scenario (see definition below).

4.3.2.1 Direct Spray

<u>Direct Spray on Receptors</u> - In this scenario it is assumed that a receptor is accidentally sprayed with an herbicide active ingredient because the receptor has entered a spray area and is beneath a spray aircraft or other mode of application. Direct spray contact is evaluated for the following receptors:

- Adult Receptor - hiker/hunter, berry picker, angler, nearby resident, and Native American
- Child Receptor - berry picker, nearby resident, and Native American

<u>Contact with Directly Sprayed Vegetation</u> - Re-entry is a term used to describe entering an area that has just been sprayed (i.e., an "on-site" area, in contrast with the scenarios in the previous section where exposure to areas of "off-site" spray drift deposition is evaluated). Contact with just-sprayed vegetation may result in dermal exposure by hikers, berry pickers, and anglers. In addition, berry pickers may ingest directly sprayed fruit. This scenario is also evaluated for the aquatic use of 2,4-D, assuming inadvertent spraying of terrestrial vegetation.

Dermal contact with just-sprayed vegetation is evaluated for:

- Adult Receptor - hiker/hunter, berry picker, angler, nearby resident (lawn), and Native American
- Child Receptor - berry picker, nearby resident (lawn), and Native American

Ingestion of directly sprayed berries is evaluated for:

- Adult Receptor - berry picker and Native American
- Child Receptor - berry picker and Native American

<u>Direct Spray onto Water Body</u> - Direct spray onto water bodies could occur inadvertently during applications of the terrestrial herbicide active ingredients, as well as the categories of aquatic 2,4-D that involve aerial and ground boom methods. Because the form of 2,4-D used to treat submerged vegetation on a water body bottom is applied via boat only, accidental sprays are not possible. Therefore, exposure to a water body treated with this type of 2,4-D is a re-

entry scenario (similar to the foliage contact scenario described above), assuming a receptor enters a treated water body even though warning signs are posted. Re-entry could also occur at any pond treated with 2,4-D via any application method. Therefore, both the accidental spray of a non-target pond and the re-entry scenarios apply to the forms of 2,4-D used to treat floating and emerged vegetation, and submerged vegetation, in a volume of water. The exposure scenarios for the inadvertently sprayed and treated water bodies are the same; therefore, separate calculations are not conducted. Incidental ingestion and dermal contact with water while swimming is evaluated for:

- Adult Receptor - swimmer
- Child Receptor - swimmer

In addition, the Native American child and adult receptors are evaluated for dermal contact while swimming and ingesting drinking water. While incidental ingestion of water could occur while swimming, this type of incidental ingestion was not evaluated separately because it results in minimal exposure, as compared to drinking water exposure (which is also evaluated in the HHRA).

An angler could fish in and ingest fish from a directly sprayed water body, or from a water body that has recently been treated. Therefore, fish ingestion is evaluated for:

- Adult Receptor - angler and Native American
- Child Receptor - Native American

In addition, hikers, berry pickers, anglers, and Native American receptors could get part of their day's drinking water from a directly sprayed water body or from a water body that has been recently treated. Occasional drinking water ingestion is evaluated for:

- Adult Receptor - hiker/hunter, berry picker, angler, and Native American
- Child Receptor - berry picker and Native American

4.3.2.2 Spills

Members of the public may be exposed to an herbicide active ingredient in water if a load of herbicide mixture is spilled, or if a container of herbicide concentrate breaks open and spills into a pond. Under this scenario, it is assumed that a fully loaded truck or helicopter empties its contents into a pond while transporting herbicide to an application site. However, because it is BLM policy to mix herbicides at the application site, this scenario represents a conservative, worst-case scenario that is unlikely to occur.

To evaluate the spill scenario, it is assumed that a pond is subjected to a spill of 140 gallons of herbicide mix from a helicopter or 200 gallons of herbicide mix from a batch truck. These amounts are approximately the largest amounts that can be carried in helicopters and trucks, respectively, during standard BLM usage.

The receptors and exposure pathways listed above for the directly sprayed water body are also evaluated for the water body that has received a direct spill. However, an accidental spill scenario is not evaluated for boat applications of 2,4-D to treat submerged vegetation on a water body bottom, as a granular form of 2,4-D is used. It is assumed that the boat would carry only the amount of 2,4-D necessary for treatment of the pond. While it is possible that a truck carrying the herbicide to the application site could spill its load into a non-target pond, it is not expected that the concentration would be any greater than that calculated for the re-entry scenario, based on the maximum application rate for the granular product of 38 lbs a.e./acre. Therefore, a separate spill scenario is not necessary.

4.3.3 Exposure Parameters for Public Receptors

Specific exposure parameters for each public receptor scenario are provided in Table 4-5. Exposure parameters are the same for routine-use and accidental scenarios. Various guidelines and databases, such as the USEPA's EFH (USEPA 2011a) and the *SOPs for Residential Pesticide Exposure* (USEPA 2012a) were used to develop the exposure parameters. For each exposure scenario, the exposure parameters were used to calculate an exposure factor (EF), which was then used in the risk calculations presented in Appendix B. The use of the EF combines all the exposure parameters into one value in order to simplify the risk calculations. The EF equations are presented in Section 5.2.2. All adult receptors are assumed to weigh 79.5 kg (175 lbs), and child receptors (age 0 to 6) are assumed to weigh 15 kg (33 lbs; USEPA 2012a). The adult body weight is the mean body weight for adult males and females aged 16 to 80. The child body weight was calculated based on data for children (males and females) aged 6 months to 6 years presented in USEPA (2012a) as follows: ([1 year * 9.2 kg (20 lbs) + 1 year * 11.4 kg (25 lbs) + 1 year * 13.8 kg (30 lbs) + 3 years * 18.6 kg (41 lbs)]/6 years).

4.3.3.1 Hiker/Hunter

It is assumed that the hiker/hunter (adult) could be exposed to herbicide active ingredients via dermal contact with spray, dermal contact with sprayed foliage, and ingestion of drinking water from a sprayed pond. Table 4-5 presents the exposure parameters for these pathways. As noted previously, a hiker/hunter child was not included. The berry picker child evaluation provides a conservative estimate of potential risks for children age 0 to 6 who participate in hiking and/or hunting.

It is assumed that the hiker/hunter ingests 2 L of water while hiking, which is the USEPA default daily drinking water ingestion rate (USEPA 1991). It is assumed that the hiker/hunter will acquire all of his/her drinking water on each day of activity from an impacted water body. It is assumed that the hiker/hunter's lower legs, lower arms, and hands are exposed, allowing potential contact with herbicide active ingredients. The 50th percentile surface area of the head, lower legs, forearms, and hands for men and women is 5,700 square centimeters (cm^2), based on the recommendation in the USEPA's dermal risk assessment guidance (USEPA 2004). The hiker/hunter is assumed to contact foliage for 2.5 hours per day. This is the 50th percentile value for time spent outdoors away from dwellings or vehicles (USEPA 2011a). The dermal Transfer Coefficient (Tc) is used to estimate the amount of herbicide active ingredient that may be transferred from foliage to skin. Tc values are available for a number of crops in USEPA (2011b). The Tc value for scouting grapes of 640 cm^2/hour was selected as the most representative value for the hiker/hunter, based on personal communication (J. Evans, USEPA OPP personal communication, February 9, 2012).

4.3.3.2 Berry Picker

It is assumed that berry pickers (adult and child) could be exposed to herbicide active ingredients via dermal contact with spray, dermal contact with sprayed foliage, ingestion of drinking water from a sprayed pond, and ingestion of berries containing spray. Table 4-5 presents the exposure parameters for these pathways.

It is assumed that an adult berry picker ingests 2 L of water while berry picking, and that a child berry picker ingests 1 L of water while berry picking (the USEPA default drinking water ingestion rates; USEPA 1991). It is assumed that berry pickers acquire all of their drinking water on each day of activity from an impacted water body. It is assumed that the berry pickers' lower legs, lower arms, and hands are exposed, allowing potential contact with herbicide active ingredients. The 50th percentile surface area of the head, lower legs, forearms, and hands for adult men and women is 5,700 cm^2 (USEPA 2004). The 50th percentile surface area of the head, lower legs, forearms, feet, and hands for children is 2,800 cm^2. It is assumed that the adult and child berry pickers contact foliage for 2.5 hours per day (USEPA 2011a). The Tc value for harvesting lowbush blueberries of 1,100 cm^2/hour was selected as the most representative value for the adult berry picker, based on personal communication (J. Evans, USEPA OPP personal communication, February 9, 2012). The child Tc value of 363 cm^2/hour was calculated by multiplying the adult value by a surface area adjustment factor of 0.33, which was calculated based on data presented in USEPA (2012a) for children aged 6 months to 6 years ([1 year * 0.23 + 1 year * 0.27 + 1 year * 0.31 + 3 years * 0.39]/6 years).

Due to the lack of available data regarding wild berry ingestion rates, berry ingestion rates for this receptor were assumed to be the same as those used for the Native American adult and child receptor discussed in Section 4.3.3.6. In a study involving the Spokane Tribe, the listed total vegetal ingestion rate for an adult is 1,600 (g/day), of which 20% is aboveground gathered terrestrial vegetation (Harper et al. 2002). Therefore, the berry ingestion rate was conservatively calculated as 1,600 g/day * 20%, or 320 g/day. Berries are likely to be a small fraction of this 320 g/day. However, since this rate was not subdivided into additional categories, it was conservatively assumed that the ingestion rate for berries is 320 g/day for an adult Native American. The use of this value for the berry picker receptor is conservative because the berry ingestion rate for the berry picker is likely to be lower than that for the Native American, who could have a higher rate of subsistence activities. For the child berry picker, the ingestion rate was scaled by body weight (i.e., 320 g/day * 15 kg / 79.5 kg) to 60 g/day.

As shown in Table 4-5, the berry ingestion rate was converted to units of cm^2/day because of the equation used to evaluate this pathway. Section 5.2.2.6 provides more details on this conversion.

4.3.3.3 Angler

It is assumed that the angler (adult) could be exposed to herbicide active ingredients via dermal contact with spray, dermal contact with sprayed foliage, ingestion of drinking water from a sprayed pond, and ingestion of fish from a sprayed pond. Table 4-5 presents the exposure parameters for these pathways. As discussed previously, a child recreational angler receptor was not included. The evaluation of the Native American child receptor includes fish ingestion and provides a conservative estimate of potential risks for young children (age 0 to 6) ingesting fish.

It is assumed that the angler ingests 2 L of water while fishing (USEPA 1991). It is assumed that the angler's lower legs, lower arms, and hands are exposed, allowing potential herbicide active ingredient contact. The 50th percentile surface area of the head, lower legs, forearms, and hands for adult men and women is 5,700 cm^2 (USEPA 2004). It is assumed that the angler contacts foliage for 2.5 hours per day (USEPA 2011a). A Tc value of 640 cm^2/hour (USEPA, 2011b) was selected for the angler, which is the same value used for the hiker/hunter. Very few studies documenting recreational angler ingestion rates of freshwater fish are available. The USEPA does not provide a specific recommendation, but does compile information from several studies in the EFH (USEPA 2011a). The highest 95th percentile rate listed is 61 g/day based on a study of active consumers of freshwater fish in Indiana. This value is therefore used as a conservative estimate of potential fish ingestion rates. Note that while the EFH lists a higher mean value for fish intake from the Savannah River in Georgia, this higher river value is not applicable to potential risks from exposure to pond fish.

4.3.3.4 Swimmer

It is assumed that swimmers (adult and child) could be exposed to herbicide active ingredients via dermal contact with and incidental ingestion of water from a sprayed pond. The USEPA (2004) recommends an exposed surface area of 18,000 cm^2 for an adult swimmer and 6,600 cm^2 for a child swimmer. It is assumed that an adult ingests 71 milliliters (mL) of water per hour while swimming, and a child ingests 120 mL of water per hour while swimming. These are the 95th percentile estimates from the USEPA EFH (USEPA 2011a). Note that the average estimates are 49 mL per hour for children and 21 mL per hour for adults. Swimming is assumed to occur for a 1-hour period, based on data presented in Table ES-1 of USEPA (2011a). The table presents a range of data for swimming exposure times for adults and children. The 95th percentile estimate for adults and children is 181 minutes/month. It is assumed that 1/3 of this time is on BLM lands (60 minutes).

4.3.3.5 Nearby Resident

It is assumed that nearby residents (adult and child) could be exposed to herbicide active ingredients via dermal contact with spray and dermal contact with sprayed lawn. Table 4-5 presents the exposure parameters for these pathways.

It is assumed that the residents' lower legs, lower arms, and hands are exposed, allowing potential contact with herbicide active ingredients. The 50th percentile surface area of the head, lower legs, forearms, and hands for adult men and women is 5,700 cm^2 (USEPA 2004), and the 50^{th} percentile surface area of the head, lower legs, forearms, feet, and hands for children is 2,800 cm^2 (USEPA 2004). It is assumed that the adult and child resident contact the lawn in the yard for 1.5 hours per day (USEPA 2012a). A Tc value of 180,000 cm^2/hour was selected for the adult resident (USEPA 2012a), and a Tc value of 59,400 cm^2/hour was calculated for the child resident based on the adult value multiplied by the surface area adjustment factor of 0.33 calculated in Section 4.3.3.2 (USEPA 2012a). These Tc values are higher than those used for the other receptors because they assume contact with herbicide active ingredients on the lawn could occur in the residents' yards (i.e., playing in the grass is an activity that could result in greater transfer than walking through the brush or woods).

4.3.3.6 Native American

It is assumed that Native American receptors (adult and child) could be exposed to herbicide active ingredients via dermal contact with spray, dermal contact with sprayed foliage, ingestion of drinking water from a sprayed pond, ingestion of berries containing spray, dermal contact with water in a sprayed pond, and ingestion of fish from a sprayed pond. Table 4-5 presents the exposure parameters for these pathways.

It is assumed that an adult Native American ingests 1 L of water per day (1 L/day) from the sprayed pond (Harper et al. 2002). The representative Spokane Tribe subsistence exposure scenario assumes that an adult consumes 4 L/day, out of which 2 L/day are consumed from a home drinking water well, 1 L/day is consumed at a work site, and 1 L/day is consumed in a sweat lodge (where water is poured over hot rocks to create a steam bath; Harper et al. 2002). It is assumed that the 1 L/day from the work site could come from a sprayed pond. It is assumed that a Native American child consumes half the adult rate, or 0.5 L/day, from a sprayed pond.

Harris and Harper (1997) and Harper et al. (2002) do not provide specific data on Native American body surface area or body weight. It is assumed that the Native American's lower legs, lower arms, and hands are exposed, allowing potential contact with herbicide active ingredients. The 50^{th} percentile surface area of the head, lower legs, forearms, and hands for adult men and women is 5,700 cm^2 (USEPA 2004). The 50^{th} percentile surface area of the head, lower legs, forearms, feet, and hands for children is 2,800 cm^2 (USEPA 2004). It is assumed that Native American receptors contact foliage for 3 hours per day of subsistence activities (Harper et al. 2002). The same Tc values used for the berry picker adult (1,100 cm^2/hour) and berry picker child (363 cm^2/hour) were used for the Native American adult and child, based on personal communication (J. Evans, USEPA OPP personal communication, February 9, 2012).

The USEPA (2004) recommends an exposed surface area of 18,000 cm^2 for an adult swimmer and 6,600 cm^2 for a child swimmer. Because no additional data are available for Native Americans, these estimates have also been used to evaluate the Native American child and adult in this HHRA. The exposure time and frequency for swimming is assumed to be 2.6 hours/day for 70 days/year, in accordance with Harris and Harper (1997). Incidental ingestion during swimming is not evaluated for Native American receptors, since the HHRA assumes that the pond is also used as a source of drinking water; any incidental ingestion during swimming is therefore included in the drinking water scenario.

The berry ingestion rate was developed from information on the Spokane Tribe in Harper et al. (2002), which lists an ingestion rate of 320 g/day for an adult for aboveground gathered terrestrial vegetation. Berries are likely to be a small fraction of this 320 g/day. However, since this rate was not subdivided into additional categories, it was conservatively assumed that the Native American ingestion rate for berries is 320 g/day for an adult. For the Native American child, the ingestion rate was scaled by body weight (i.e., 320 g/day * 15 kg / 79.5 kg) to 60 g/day (per California EPA 1996).

Based on a high fish diet scenario discussed in Harper et al. (2002), the adult fish ingestion rate was assumed to be 885 g/day. The high fish diet consists primarily of fish, supplemented by big game, aquatic amphibian/crustacean/ mollusks, small mammals, and upland game birds. This value is much higher than the highest 95^{th} percentile fish ingestion rate of 170 g/day listed in USEPA (2011a; Table 10-6) for a Native American subsistence population. For the Native American child, the ingestion rate was scaled by body weight (i.e., 885 g/day * 15 kg/79.5 kg) to 167 g/day (per California EPA 1996).

4.4 Calculation of Exposure Point Concentrations

Exposure points are located where potential receptors may contact herbicide active ingredients. In order to determine the magnitude of the potential exposure, the concentration of herbicide active ingredient in the environmental medium that receptors may contact must be estimated. The concentration at the point of contact is referred to as the exposure point concentration (EPC).

4.4.1 Occupational Exposures

It is assumed that workers could be exposed via dermal contact and inhalation through routine use of herbicide active ingredients and via an accidental spill onto worker skin.

Routine Exposures - For the routine exposures, the exposure dose is calculated using the herbicide active ingredient application rate (in pounds of a.i. or a.e/acre) and the acres treated per day. This information is provided in Tables 4-1 and 4-2.

Accidental Exposures - To calculate exposures from an accidental spill onto worker skin, the concentration of a.i. or a.e. in the formulation (in pounds of a.i. or a.e. per gallon of formulation) must be derived. These concentrations are provided, or can be calculated from the information provided, on the reference herbicide labels (Appendix A). Four of the herbicide active ingredients evaluated in the risk assessment (aminopyralid, 2,4-D, clopyralid, and fluroxypyr) are present in a concentrated liquid formulation. One formulation of 2,4-D is granular and is applied in granular form; therefore, the accidental spill to skin scenario is not applicable. For the worker spill scenario, it is assumed that the worker is exposed to the concentrated liquid; therefore, the pounds of a.i. or a.e. per gallon listed on the labels are used for the calculation. For aminopyralid, clopyralid, 2,4-D, and fluroxypyr, the maximum concentrated liquid concentrations are listed in Table 4-6.

Rimsulfuron is in a dry form, and needs to be mixed with water before application. The concentration of active ingredient present in the application-ready formulation is calculated using the maximum application rate (in pounds of active ingredient per acre; Table 4-1) and the minimum spray rate (in gallons per acre; information provided by the BLM). The combination of maximum application rate and minimum spray rate results in the most concentrated solution. The EPC is calculated using the following equation:

$$\text{EPC (pounds a.i. or a.e./gallon)} = \frac{\text{Application rate (pounds a.i. or a.e./acre)}}{\text{Spray rate (gallons/acre)}}$$

The helicopter spray rate of 5 gallons/acre results in the most concentrated solution; therefore the helicopter spray rate is used in the calculation. Table 4-6 presents the calculation results.

As discussed in Section 5.3, the accidental spill scenario for the concentrated 2,4-D solution results in unacceptable risks to occupational receptors. Because of the unlikely nature of the scenario (i.e., a spill of concentrated liquid directly to worker skin), EPCs were also calculated assuming a spill to worker skin after 2,4-D is mixed at the maximum and typical application rates, using the equation listed above. The accidental spill scenario that assumes rimsulfuron is mixed at the maximum application rate also results in unacceptable risks; therefore, an EPC was also calculated based on the typical application rate. Table 4-7 presents the additional spill EPCs for 2,4-D and rimsulfuron.

4.4.2 Public Exposures

It is assumed that the public could be routinely exposed to herbicide active ingredients in spray drift that has deposited onto the receptor, foliage, ponds, and berries. It is also assumed that active ingredients could be accidentally directly sprayed onto the receptor, foliage, pond, and berries, or spilled directly into the pond.

4.4.2.1 Routine-use Exposure Point Concentrations

Off-target spray drift refers to the amount of sprayed herbicide that does not come into contact with the target area, but rather drifts in the air and settles on an off-target area. The magnitude of potential human exposure to herbicide active ingredients as a result of off-target spray drift and surface runoff of herbicide active ingredients from the target application area was estimated from modeled terrestrial deposition rates and water body concentrations. A hypothetical ¼-ac, 1-m-deep pond was assumed for these calculations. Off-target spray drift and resulting terrestrial deposition rates and water body concentrations were predicted using the computer model, AgDRIFT® (Spray Drift Task Force [SDTF] 2002). Surface runoff of herbicide active ingredients from the target application area and resulting water body (hypothetical pond) concentrations were predicted using the computer model Groundwater Loading Effects of Agricultural Management Systems (GLEAMS).

Modeling was conducted assuming the acid form of all herbicide active ingredients. For the ecological risk assessment (AECOM 2014), modeling of the ester form of 2,4-D was also performed because of differences in the toxicity of the acid/salt forms and the ester forms to certain aquatic species. For human health, however, all forms of 2,4-D are considered toxicologically equivalent (USEPA 2005b). Additionally, modeled concentrations of the acid form in water are higher than those estimated for the ester form. Therefore, use of the estimated pond concentrations for the acid form results in the most conservative estimate of potential human health risk.

AgDRIFT®

The AgDRIFT® Version 2.0.05 (SDTF 2002) computer model is a product of the Cooperative Research and Development Agreement between the USEPA's Office of Research and Development and the SDTF (a coalition of pesticide registrants). It is based on, and represents an enhancement of, its preceding computer program, AGDISP (Agricultural Dispersal Model), which was developed by the National Aeronautics and Space Administration, the Forest Service, and the U.S. Army. AgDRIFT® was developed for use in regulatory assessments of off-target drift associated with agricultural use of pesticides through aerial, ground, or orchard/airblast applications. AgDRIFT® is based on the simple idea that pesticide or herbicide drift is primarily a function of application technique (e.g., droplet size and release height), environmental conditions, and physical properties of the spray solution, rather than the active ingredient itself. To implement this idea, the computational approach employed by AgDRIFT® is based on a simple method that has evolved over a period of more than 20 years and yields high correlation with field measurement data sets. AgDRIFT® was selected for use in this risk assessment because it allows for the simulation of a broad range of aerial and ground application practices and associated off-target spray drift. Further, the cooperative development of AgDRIFT® by the USEPA and the SDTF, and the associated use of AgDRIFT® in regulatory assessments of off-target pesticide drift, reinforces its suitability to this particular application.

AgDRIFT® enables the user to take a tiered approach to the modeling of drift by allowing the user to choose between three tiers of increasingly complex evaluations of off-target drift and deposition. The basic difference between the three tiers (Tiers I, II, and III) is the amount of control users have in selecting model input variables. Also, Tier I supports the evaluation of aerial and ground application scenarios, whereas Tiers II and III support the evaluation of only aerial application scenarios (for agricultural and forestry applications). Tier I is based on a set of standard "Good Application Practices" and requires little knowledge of the actual application conditions or herbicide active ingredient properties. Tier I allows the user to modify a small number of model variables. Tiers II and III are based on the same set of "Good Application Practices" as Tier I. However, to implement either Tier II or III the user must have a progressively greater knowledge of the specific conditions under which herbicides will be applied. Tiers II and III allow the user to modify a progressively larger set of variables to make the scenario evaluated representative of the specific conditions under which herbicides will be applied.

Tier I was used in this HHRA to evaluate off-target drift associated with ground application scenarios. Tier II was used to evaluate off-target drift associated with aerial application of herbicides to agricultural and forestry land types. The agricultural land type represents land with a relatively short vegetative canopy (e.g., non-forested land such as rangeland). The forestry land type represents land with a higher vegetative canopy (e.g., forested land). The Tier I ground application model does not allow the user to select between land types. It simply models drift from ground application in an agriculture-like setting. Both Tier I and Tier II of the AgDRIFT® model were utilized to evaluate off-target spray drift to a terrestrial area or water body (e.g., a hypothetical pond) located perpendicular to, and downwind of, the herbicide application area. The terrestrial area simply represents a point on the ground at a fixed distance downwind of the application area. AgDRIFT® calculates the deposition rate for the terrestrial location of interest. The hypothetical pond is intended to represent a non-flowing water body approximately ¼ ac in area and 1 m deep. The concentration of the herbicide a.i. being modeled in pond water is generated in the AgDRIFT® model based on the assumption of instantaneous mixing throughout the water body. The implementation of the Tier I ground and Tier II aerial application models and the model input variables (including the variables specific to the application method and environmental setting and specific to the herbicide active ingredient being evaluated) are discussed and presented in Appendix C.

GLEAMS

GLEAMS is a modified version of the CREAMS (Chemical Runoff Erosion Assessment Management System) model that was originally developed to evaluate non-point source pollution from agricultural field-size areas. One of the benefits of the GLEAMS model is the ability to estimate a wide range of potential herbicide active ingredient exposure concentrations as a function of important site-specific parameters such as soil characteristics, and annual precipitation. The model simulates edge-of-field and bottom-of-root-zone loadings of water, sediment, pesticides (or herbicides), and plant nutrients from the complex climate-soil-management interactions. The GLEAMS model has evolved through several versions from its inception in 1984 to the present, and has been evaluated in numerous climatic and soil regions around the world. The model was selected for use in this investigation because of its widespread acceptance, its suitability to this particular application, and the previous use of the model to support similar risk assessments for the Forest Service (SERA 2001).

In this application, the GLEAMS model was used to simulate the fate and transport of the terrestrial forms of the herbicide active ingredients considered in this HHRA from an area representing a typical BLM application area. The fate and transport of the herbicide active ingredients was simulated by GLEAMS using a precipitation record and three other model components intended to represent hydrology, erosion, and pesticide movement:

- *Precipitation Record* **-** Rainfall distribution was described in the GLEAMS model using a daily hyetograph from Medford, Oregon from 1990, when a total of approximately 13.5 inches of precipitation was recorded. The GLEAMS model used the hyetograph from 1990 to describe the annual distribution of precipitation during the model simulations and eight different precipitation totals, including 5, 10, 25, 50, 100, 150, 200, and 250 inches/year. By scaling the eight different hypothetical precipitation totals by the precipitation record measured during 1990, the daily rainfall totals were increased in the model, while the annual distribution of precipitation was retained.

- *Hydrology* **-** The hydrology component of the GLEAMS model simulates the movement of water through an agricultural system by considering the effects of precipitation on surface runoff and percolation through the unsaturated zone. Three soil types were simulated in this application: silt, sand, and clay. The simulated application area was a 10-acre square with a 5% slope, and the climate applied to the simulation was the measured annual average at Medford, Oregon.

- *Erosion* **-** The erosion component of GLEAMS simulates the movement of sediment over the land surface using the Universal Soil Loss Equation (USLE). Typical values were used to represent the soil erodibility factor and a Manning Roughness coefficient.

- *Pesticide* **-** The pesticide component of the GLEAMS model was used to simulate the movement of the herbicide active ingredients through the ecosystem by associating the herbicide active ingredients with both water and sediment. Literature values describing water solubility, foliar half-life, partitioning, washoff, and soil half-life were used to facilitate the GLEAMS model calculations.

The GLEAMS model was used to simulate the fate and transport and eventual water body (e.g., pond) loading of each of the terrestrial herbicide active ingredients, assuming each was applied to a single application area within the vicinity of a hypothetical pond, and using combinations of each of the eight precipitation rates and the three soil types.

Ambient water concentrations were calculated for a pond immediately adjacent to the application field using model-predicted runoff and percolation rates, and the mass of herbicide active ingredient associated with each of these exports. Statistical values of concentrations were calculated using an entire year of predicted results, which were extracted once the model had reached a quasi-steady state. The GLEAMS model provides daily predictions of herbicide a.i. export rates, which were used to calculate ambient water concentrations in a pond. The daily values were used to determine short-term (7-day), intermediate-term (30-day), and long-term (annual) surface water concentrations. These exposure durations correspond to the exposure durations used to evaluate the toxicology endpoint data in Section 3 (Table 3-1). Long-term concentrations were calculated as the annual daily average from the last year of the 10-year simulation. Intermediate-term concentrations were calculated as the maximum 30-day average from the last year of the 10-year simulation. Short-term concentrations were calculated as the maximum 7-day average from the last year of the 10-year simulation. While it is possible that public receptors use public lands under intermediate and long-term time frames, it is unlikely that public receptors would be exposed to herbicides under the routine-use scenario for more than a short-term exposure, which is defined as up to 30 days (USEPA 2012a). Therefore, short-term concentrations are used to evaluate the public receptors under the routine-use exposure scenario. An evaluation of the public receptors under an intermediate- and a long-term exposure scenario is included in the Uncertainty Analysis (Section 5.5).

Ambient herbicide active ingredient concentrations were calculated for a ¼-ac, 1-m-deep pond by assuming a fixed pond volume and a daily-predicted inflow of herbicide active ingredient and water to the pond. Herbicide active ingredient and water exported from the application area, displaced water and herbicide active ingredient in the pond, and a volume-weighted concentration were calculated and updated on a daily basis. Because the pond has a fixed volume, the concentration resulting from an influx of runoff and percolation water replaces an equal volume of pond water. In addition to the effect of runoff and percolation water, natural decay processes were considered in the model.

Pond concentrations for 42 scenarios were calculated for each time frame (18 from varying soil type and precipitation totals and 24 from a sensitivity analysis in which soil type and 5 other parameters were varied). The highest calculated pond concentrations were selected from all of the scenarios for each time frame in order to provide the most conservative pond concentrations as an input to the HHRA. The time frames were selected to correlate with the USEPA's short-term, intermediate-term, and long-term NOAELs (Section 3.1.2). A detailed discussion of the GLEAMS modeling approach is presented in Appendix D. Ecological risk assessment reports developed for each herbicide active ingredient contain a description of GLEAMS model inputs specific to each herbicide active ingredient, and present a summary of GLEAMS model results for each herbicide active ingredient (AECOM 2014).

Terrestrial Deposition Rates and Exposure Point Concentrations

The initial terrestrial deposition rates predicted using the AgDRIFT® Tier I ground application and Tier II aerial application models, presented in Table 4-8, were used to evaluate the following potential human exposure pathways:

- Dermal contact with herbicide active ingredient in spray drift
- Dermal contact with herbicide active ingredient on foliage
- Ingestion of herbicide active ingredient that has deposited on berries

Spray drift deposition rates were estimated for two application scenarios, aerial and ground. For the aerial scenario, AgDRIFT® evaluates two land types (non-forested and forested) for estimation of deposition rates. As the non-forested land type represents land with a relatively short vegetative canopy, it was used to estimate spray drift deposition rates resulting from aerial applications over non-forested areas, while the forested land type (representing land with a higher vegetative canopy) was used to estimate spray drift deposition rates resulting from aerial applications over forested areas. To encompass all possibilities, both sets of deposition rates were used to evaluate public receptor exposures. Deposition rates were also calculated separately for airplane and helicopter applications. The primary difference between the airplane and helicopter application scenarios is the speed at which the aircraft traverses the application area; the higher the speed of the aircraft, the greater the off-site drift. If herbicides are applied aerially in a manner consistent with best practices, a helicopter will traverse the application area at lower speeds; resulting in lower off-site drift. The following four sets of aerial deposition rates (presented in Table 4-8) were calculated using Tier II of the model for each herbicide active ingredient:

- Non-forested land type, airplane application
- Non-forested land type, helicopter application
- Forested land type, airplane application
- Forested land type, helicopter application

Off-target spray drift and the resulting terrestrial impacts from the aerial application scenarios were predicted at distances of 100, 300, and 900 feet downwind of the herbicide application area. The closest distance to the receptor (i.e., 100 feet downwind), was used as the basis for the human health risk assessment.

For ground applications using Tier I of the model, estimation of spray drift deposition rate is not dependent on land type. Therefore, under land type for ground applications, Table 4-8 indicates "Not Applicable," meaning that the deposition rates apply to any land type. Ground applications may be conducted using either a high boom (spray boom height set at 50 inches above the ground) or a low boom (spray boom height set at 20 inches above the ground), and deposition rates vary by the height of the boom (the higher the height of the spray boom, the greater the off-site drift). Therefore, two sets of ground deposition rates are calculated and presented in Table 4-8 for each herbicide active ingredient:

- Ground application, low boom
- Ground application, high boom

Off-target spray drift and the resulting terrestrial impacts from the ground application scenarios were predicted at distances of 25, 100, and 900 feet downwind of the herbicide application area. The closest distance to the receptor (i.e., 25 feet downwind) was used as the basis for the human health risk assessment.

Pond Exposure Point Concentrations

The surface water (pond) herbicide active ingredient EPCs predicted using AgDRIFT® represent short-lived concentrations due to off-target spray drift. It is likely that these predicted herbicide active ingredient levels are flushed out of the hypothetical pond within a few days. For the aquatic use of 2,4-D, it is assumed that the herbicide is sprayed onto a target pond and the spray drift settles onto an adjacent pond that was not targeted for spraying.

The pond herbicide active ingredient EPCs predicted using the GLEAMS model represent the potential impact of surface runoff of terrestrial herbicide active ingredient and assume a constant loading to the pond. Therefore, the GLEAMS EPCs represent potential longer-term concentrations in the pond. The processes of spray drift onto and surface runoff into a surface water body are not directly additive, since they may not occur over the same time frame. However, as a conservative approach, the hypothetical herbicide active ingredient EPCs due to spray drift predicted using AgDRIFT® were used in calculating the short-, intermediate-, and long-term surface water exposure point concentrations for all herbicide active ingredients. The short-, intermediate-, and long-term EPCs of terrestrial herbicide active ingredients calculated using the GLEAMS model were added to the AgDRIFT® predictions for those herbicide active ingredients. Using the AgDRIFT® output for short-, intermediate-, and long-term time frames is a conservative approach, since AgDRIFT® mainly represents short-lived concentrations. These combined EPCs are used to evaluate:

- Dermal contact with herbicide active ingredient in water while swimming

- Ingestion of herbicide active ingredient in water used as drinking water or while swimming
- Ingestion of herbicide active ingredient that may bioconcentrate in the edible tissue of recreationally caught fish

The pond EPCs calculated using AgDRIFT® are presented in Table 4-9. As for the terrestrial deposition rates, pond EPCs were calculated for several land types and application scenarios:

- Non-forested land type, airplane application
- Non-forested land type, helicopter application
- Forested land type, airplane application
- Forested land type, helicopter application
- Ground application, low boom
- Ground application, high boom

For the aquatic use of 2,4-D, the non-forested land type was used to estimate potential spray drift onto a non-target pond.

Off-target spray drift and the resulting aquatic impacts were predicted at distances 100, 300, and 900 feet downwind of the aerial application areas and 25, 100, and 900 feet downwind of the ground application areas. Again, for the human health risk assessment, the nearest distances to the receptor were used (e.g., 100 feet and 25 feet downwind for the aerial and ground applications, respectively).

The highest pond EPCs for the terrestrial herbicide active ingredients calculated using GLEAMS are presented in Table 4-10. Table 4-11 presents the calculation of the combined GLEAMS and AgDRIFT® pond EPCs for terrestrial herbicide active ingredients. The final selected estimated short-, intermediate-, and long-term surface water EPCs are presented in Table 4-12.

The use of a pond to predict potential human health risks from exposure to spray drift or runoff containing herbicides is expected to be representative of potential exposures in other water bodies, including rivers, streams, and ditches.

4.4.2.2 Accidental Exposure Point Concentrations

Direct spray - Accidental exposures involving direct spray are estimated using the herbicide active ingredient application rates (in pounds of a.e. or a.i. per acre) shown in Table 4-1. It is assumed that the herbicide a.i. is sprayed at the maximum application rate directly onto the receptor, foliage, berries, or pond. Pond concentrations resulting from a direct spray event are presented in Table 4-13, assuming a 1/4-ac pond, 1 m (3.28 feet) deep. The equation used to calculate the pond concentration is as follows:

$$Pond\ EPC\ (mg/L) = \frac{App.Rate(lb\,a.e.or\,a.i./acre) * 453{,}600\,mg/lb * 35.31\,ft^3/m^3 * 0.001m^3/L}{43{,}560\,ft^3/acre *\ pond\ depth\,(feet)}$$

Note that for the formulation of 2,4-D used to treat a volume of water, the pond depth factor is eliminated from the above equation because the application rate is in units of lb a.e./acre-foot.

As indicated in Section 5.3 of this risk assessment, both accidental spray scenarios involving 2,4-D present an unacceptable risk to public receptors. To provide a more realistic estimate of risk, EPCs were also calculated for 2,4-D assuming direct spray of a pond at the typical application rate using the equation listed above. Table 4-14 presents the additional EPCs for 2,4-D.

Spill - It is assumed that a pond receives a spill of 140 gallons of herbicide mix from a helicopter or 200 gallons of spray mix from a batch truck. These amounts are approximately the largest amounts that can be carried in helicopters and trucks, respectively, during standard BLM usage. Similar to the worker spill scenario, the concentration of a.i. in the formulation must be derived. It is assumed that the herbicide active ingredients are present in application-ready concentrations as they are being transported, even though it is BLM policy to mix herbicides for application at the application site. Therefore, for the herbicide active ingredients that may be present in concentrated liquid form (aminopyralid, clopyralid, 2,4-D, and fluroxypyr), a diluted concentration is calculated. Rimsulfuron and 2,4-D (granular) are in solid form, and the concentration of active ingredient in the application-ready formulation is calculated.

Similar to the worker spill scenario (Section 4.4.1), the following equation is used to calculate the concentration of active ingredient present in the application-ready formulation:

$$\text{Concentration (pounds a.e. or a.i./gallon)} = \frac{\text{Application rate (pounds a.e. or a.i./acre)}}{\text{Spray rate (gallons/acre or acre - feet)}}$$

Two spray rates are used in the equation to represent spraying from helicopters and trucks. Based on information provided by the BLM, the lowest spray rates are 5 gallons/acre from a helicopter and 25 gallons/acre from a truck. While a range of spray rates is possible, these spray rates represent the lower end of the range, and thus result in higher concentrations. Maximum application rates (shown in Table 4-1) were used for each of the herbicide active ingredients. The calculated concentrations for the helicopter and truck scenarios are shown in Table 4-15. The equation used to calculate the pond EPC is as follows:

$$\text{Pond EPC (mg / L)} = \frac{\text{Gal spilled} * \text{lb a.e. or a.i. / gallon} * 453{,}600\ \text{mg / lb} * 35.31\text{ft}^3 / \text{m}^3 * 0.001\text{m}^3 / \text{L}}{43{,}560\text{ft}^2 / \text{acre} * \text{pond size (acre)} * \text{pond depth (feet)}}$$

As indicated in Section 5.3 of this risk assessment, both the accidental truck and helicopter spill scenarios for 2,4-D pose unacceptable risks to public receptors. To provide a more realistic estimate of risk, EPCs were also calculated for 2,4-D assuming spills at the typical application rate using the equation listed above. Table 4-16 presents the additional EPCs for 2,4-D.

4.5 Chemical-specific Parameters

Several chemical-specific parameters are used to calculate the exposure doses described in Sections 4.5.1 to 4.5.3. These include absorption factors, skin permeability factors, and bioconcentration factors. Each parameter is described below.

4.5.1 Absorption Factors

Absorption factors are used in this HHRA when the exposure used to select the NOAEL and the exposure in the environmental medium of interest differ. A DAF of 0.1 is used with the dermal NOAELs for 2,4-D and a DAF of 0.17 is used for rimsulfuron. While oral studies were used to develop inhalation NOAELs for all five herbicides, absorption is assumed to be equal via the oral and inhalation routes, therefore, the inhalation absorption factor (IAF) is set to one (100%). The absorption factors are presented in Table 4-17.

4.5.2 Skin Permeability Constants

The estimation of exposure doses resulting from incidental dermal contact with surface water requires the use of a dermal permeability constant (Kp) in units of centimeters per hour (cm/hr). This method assumes that the behavior of constituents dissolved in water is described by Fick's Law. In Fick's Law, the steady-state flux of the solute across the skin (mg/cm^2/hr) equals the Kp (cm/hr) multiplied by the concentration difference of the solute across the membrane (mg/cubic meter [cm^3]). This approach is discussed by the USEPA (USEPA 1989, 2004). For the herbicide a.i.

evaluated in the risk assessment, Kps were calculated using an equation presented in the USEPA's *Supplemental Guidance for Dermal Risk Assessment* (USEPA 2004). The equation, the parameters used in the equation, and the calculated Kp values are presented in Table 4-18. The input parameters include the molecular weight and the log of the octanal water-partition coefficient, and were obtained from several sources (Budavari 1989, California EPA 1997, USEPA 2005a, 2005d, 2009a, b, Tomlin 2009, USDA 2009, USEPA 2009a, 2009b). For aminopyralid, clopyralid, 2,4-D, and rimsulfuron, the parameters selected represent the acid form of the herbicide active ingredient, consistent with the modeling approach. For fluroxypyr, the parameters represent the MHE form of the herbicide active ingredient. The MHE form is selected for fluroxypyr because it is expected to absorb through the skin faster than the acid form, and therefore will result in the more conservative estimate of potential risk.

4.5.3 Fish Bioconcentration Factors

To estimate concentrations of herbicide active ingredients in fish tissue, a bioconcentration factor (BCF) is used to approximate the amount of herbicide active ingredient that bioconcentrates from the water into the fish tissue. BCFs used in this risk assessment are presented in Table 4-19. The available data suggest that aminopyralid, clopyralid, 2,4-D, and rimsulfuron do not bioconcentrate, and therefore the BCFs are set to 1 (Bidlack 1982, California EPA 1997, USEPA 2005b, d). A study of bioconcentration from water into fish tissue is available for the MHE form of fluroxypyr (Rick et al. 1996; MRID 44080348). Available information suggests that the MHE form does metabolize to the acid form, although the process is not instantaneous. In the absence of a BCF for the acid form, the BCF derived for the MHE form for edible fish tissues of 6.06 L/kg is used.

Table 4-1
Summary of Herbicide Use

Herbicide Active Ingredient	Scenario	Vehicle/Method	Units	Application Rates (a)	
				Typical	Maximum
Aminopyralid	Rangeland Public-domain Forestland Energy and Mineral Sites Rights-of-way Recreation and Cultural Sites	Plane - Fixed-wing Helicopter - Rotary Backpack Horseback ATV/UTV - Spot ATV/UTV - Boom/broadcast Truck - Spot Truck - Boom/broadcast	lb a.e./acre	0.078	0.11
Clopyralid	Rangeland Public-domain Forestland Energy and Mineral Sites Rights-of-way Recreation and Cultural Sites	Plane - Fixed-wing Helicopter - Rotary Backpack Horseback ATV/UTV - Spot ATV/UTV - Boom/broadcast Truck - Spot Truck - Boom/broadcast	lb a.e./acre	0.25	0.5
2,4-D	Rangeland Public-domain Forestland Energy and Mineral Sites Rights-of-way Recreation and Cultural Sites Annual and Perennial Species	Plane - Fixed-wing Helicopter - Rotary Backpack Horseback ATV/UTV - Spot ATV/UTV - Boom/broadcast Truck - Spot Truck - Boom/broadcast	lb a.e./acre	1	2
	Rangeland Public-domain Forestland Energy and Mineral Sites Rights-of-way Recreation and Cultural Sites Woody Species	Plane - Fixed-wing Helicopter - Rotary Backpack Horseback ATV/UTV - Spot ATV/UTV - Boom/broadcast Truck - Spot Truck - Boom/broadcast	lb a.e./acre	2	4
	Aquatic Sites (Liquid) Floating and Emerged	Plane - Fixed-wing Helicopter - Rotary Backpack Horseback ATV/UTV - Spot ATV/UTV - Boom/broadcast Truck - Spot Truck - Boom/broadcast Boat - Spot Boat - Boom/broadcast	lb a.e./acre	2	4
	Aquatic Sites (Liquid) Submerged (Treating a volume of water)	Plane - Fixed-wing Helicopter - Rotary Backpack Horseback ATV/UTV - Spot ATV/UTV - Boom/broadcast Truck - Spot Truck - Boom/broadcast Boat - Spot Boat - Boom/broadcast	lbs. a.e./acre-foot	5.4	10.8
	Aquatic Sites (Granular) Submerged (Treating bottom)	Boat - Spot Boat - Boom/broadcast	lb a.e./acre	19	38

Table 4-1
Summary of Herbicide Use

Herbicide Active Ingredient	Scenario	Vehicle/Method	Units	Application Rates (a)	
				Typical	Maximum
Fluroxypyr	Rangeland Public-domain Forestland Energy and Mineral Sites Rights-of-way Recreation and Cultural Sites	Plane - Fixed-wing Helicopter - Rotary Backpack Horseback ATV/UTV - Spot ATV/UTV - Boom/broadcast Truck - Spot Truck - Boom/broadcast	lb a.e./acre	0.26	0.5
Rimsulfuron	Rangeland Public-domain Forestland	Plane - Fixed-wing Helicopter - Rotary Backpack Horseback ATV/UTV - Spot ATV/UTV - Boom/broadcast Truck - Spot Truck - Boom/broadcast	lb a.i./acre	0.0469	0.0625
	Energy and Mineral Sites Rights-of-way Recreation and Cultural Sites		lb a.i./acre	0.0625	0.0625

ATV - All-Terrain Vehicle.
UTV - Utility Vehicle.
lb a.e./acre - pounds of acid equivalent per acre.
lb a.i./acre - pounds of active ingredient per acre.
lbs. a.e./acre-foot - pounds of acid equivalent per acre-foot.
(a) - All data are based on a single application.

Table 4-2
Exposure Parameters for Occupational Receptors

Application Type (Scenario)	Application Vehicle	Application Method	Receptor	Exposure Parameters (a)							Application Parameters				Unit Exposures (b)			
				Hours Per Day		Days Per Year		Years of Exposure		Body Weight (c)	Acres Treated Per Hour (d)		Acres Treated Per Day (e)		Dermal (long-sleeved shirt and pants)			Inhalation
				Typical	Maximum	Typical	Maximum	Typical	Maximum	(kg)	Typical	Maximum	Typical	Maximum	Gloves (mg/lb a.i.)	No Gloves (mg/lb a.i.)	Selected (f) (mg/lb a.i.)	Typical (mg/lb a.i.)
Aerial	Plane	Fixed Wing	Pilot	4	6	16	41	6	33	79.5	250	500	1000	3000	Not provided	0.005	0.005	0.000068
			Mixer/Loader (g)	4	6	16	41	6	33	79.5	250	500	1000	3000	0.0376	0.22	0.0376	0.000291
	Helicopter	Rotary	Pilot	4	6	10	16	11	24	79.5	100	200	400	1200	Not provided	0.005	0.005	0.000068
			Mixer/Loader (g)	4	6	10	16	11	24	79.5	100	200	400	1200	0.0376	0.22	0.0376	0.000291
Ground	Human	Backpack	Applicator/Mixer/Loader	3	6	22	30	6	25	79.5	0.2	0.4	0.6	2.4	8.26	8.26	8.26	0.00258
		Horseback	Applicator/Mixer/Loader	6	8	50	76	15	50	79.5	0.75	1	4.5	8	8.26	8.26	8.26	0.00258
	ATV/UTV	Spot	Applicator	5	9	50	76	6	24	79.5	0.25	0.5	1.25	4.5	1.3	0.39	1.3	0.0039
			Mixer/Loader (g)	3	6	50	76	6	24	79.5	0.25	0.5	0.75	3	0.0376	0.22	0.0376	0.000291
			Applicator/Mixer/Loader (g,h)	5	9	50	76	6	24	79.5	0.25	0.5	1.25	4.5	1.3376	0.61	1.3376	0.004191
		Boom/Broadcast	Applicator	5	9	39	60	6	24	79.5	0.8	1.6	4	14.4	0.0161	0.0786	0.0161	0.00034
			Mixer/Loader (g)	3	5	39	60	6	24	79.5	0.8	1.6	2.4	8	0.0376	0.22	0.0376	0.000291
			Applicator/Mixer/Loader (g,h)	5	9	39	60	6	24	79.5	0.8	1.6	4	14.4	0.0537	0.2986	0.0537	0.000631
	Truck Mount	Spot	Applicator	6	10	60	90	7	30	79.5	0.38	1	2.28	10	1.3	0.39	1.3	0.0039
			Mixer/Loader (g)	4	8	60	90	7	30	79.5	0.38	1	1.52	8	0.0376	0.22	0.0376	0.000291
			Applicator/Mixer/Loader (g,h)	6	10	60	90	7	30	79.5	0.38	1	2.28	10	1.3376	0.61	1.3376	0.004191
		Boom/Broadcast	Applicator	5	8	49	74	6	19	79.5	1.5	2.25	7.5	18	0.0161	0.0786	0.0161	0.00034
			Mixer/Loader (g)	3	6	49	74	6	19	79.5	1.5	2.25	4.5	13.5	0.0376	0.22	0.0376	0.000291
			Applicator/Mixer/Loader (g,h)	5	8	49	74	6	19	79.5	1.5	2.25	7.5	18	0.0537	0.2986	0.0537	0.000631
Aquatic (Granular)	Boat	Spot	Applicator/Mixer/Loader	4	6	12	19	6	23	79.5	0.75	1.5	3	9	0.0069	0.0084	0.0069	0.0017
		Boom/Broadcast	Applicator/Mixer/Loader	4	6	12	19	6	23	79.5	1	2	4	12	0.0069	0.0084	0.0069	0.0017
Aquatic (Liquid)	Boat	Spot	Applicator	4	6	12	19	6	23	79.5	0.63	2	2.52	12	1.3	0.39	1.3	0.0039
			Mixer/Loader (g)	1	2	3	4	6	23	79.5	0.63	2	0.63	4	0.0376	0.22	0.0376	0.000291
			Applicator/Mixer/Loader (g,h)	4	6	12	19	6	23	79.5	0.63	2	2.52	12	1.3376	0.61	1.3376	0.004191
		Boom/Broadcast	Applicator	4	6	12	19	6	23	79.5	1.3	3	5.2	18	0.0161	0.0786	0.0161	0.00034
			Mixer/Loader (g)	1	2	3	4	6	23	79.5	1.3	3	1.3	6	0.0376	0.22	0.0376	0.000291
			Applicator/Mixer/Loader (h)	4	6	12	19	6	23	79.5	1.3	3	5.2	18	0.0537	0.2986	0.0537	0.000631

a.i.- Active ingredient.
ATV - All-Terrain Vehicle.
UTV - Utility Vehicle.
NA - Not Applicable.
(a) - With the exception of body weight, exposure parameters were provided by BLM personnel familiar with herbicide use in the vegetation treatment program.
(b) - See Table 4-3 for references. Values are expressed in terms of active ingredient, which for this purpose is the same as acid equivalent.
(c) - USEPA 2012a. Standard Operating Procedures for Residential Pesticide Exposure Assessment. Mean body weight for adult males and females (age 16 to 80).
(d) - Information provided by BLM personnel familiar with herbicide use in the vegetation treatment program; see Table 4-1.
(e) - Acres treated per hour * hours per day.
(f) - All receptors are assumed to wear gloves with the exception of pilots, per BLM policy.
(g) - Rimsulfuron is available in either a dry flowable or water-soluble granule form. The mixing/loading values from USEPA 2012b for dry flowable formulations are therefore applicable for mixing and loading of rimsulfuron (see Table 4-3).
(h) - Sum of Applicator and Mixer Loader unit exposures.

Table 4-2
Exposure Parameters for Occupational Receptors

Application Type (Scenario)	Application Vehicle	Application Method	Receptor	Exposure Parameters (a): Hours Per Day – Typical	Hours Per Day – Maximum	Days Per Year – Typical	Days Per Year – Maximum	Years of Exposure – Typical	Years of Exposure – Maximum	Body Weight (c) (kg)	Application Parameters: Acres Treated Per Hour (d) – Typical	Acres Treated Per Hour (d) – Maximum	Acres Treated Per Day (e) – Typical	Acres Treated Per Day (e) – Maximum	Unit Exposures (b): Dermal (long-sleeved shirt and pants) – Gloves (mg/lb a.i.)	Dermal – No Gloves (mg/lb a.i.)	Dermal – Selected (f) (mg/lb a.i.)	Inhalation – Typical (mg/lb a.i.)
Aerial	Plane	Fixed Wing	Pilot	4	6	16	41	6	33	79.5	250	500	1000	3000	Not provided	0.005	0.005	0.000068
			Mixer/Loader	4	6	16	41	6	33	79.5	250	500	1000	3000	0.0376	0.22	0.0376	0.000291
	Helicopter	Rotary	Pilot	4	6	10	16	11	24	79.5	100	200	400	1200	Not provided	0.005	0.005	0.000068
			Mixer/Loader	4	6	10	16	11	24	79.5	100	200	400	1200	0.0376	0.22	0.0376	0.000291
Ground	Human	Backpack	Applicator/Mixer/Loader	3	6	22	30	6	25	79.5	0.2	0.4	0.6	2.4	8.26	8.26	8.26	0.00258
		Horseback	Applicator/Mixer/Loader	6	8	50	76	15	50	79.5	0.75	1	4.5	8	8.26	8.26	8.26	0.00258
	ATV/UTV	Spot	Applicator	5	9	50	76	6	24	79.5	0.25	0.5	1.25	4.5	1.3	0.39	1.3	0.0039
			Mixer/Loader	3	6	50	76	6	24	79.5	0.25	0.5	0.75	3	0.0376	0.22	0.0376	0.000291
			Applicator/Mixer/Loader (g)	5	9	50	76	6	24	79.5	0.25	0.5	1.25	4.5	1.3376	0.61	1.3376	0.004191
		Boom/Broadcast	Applicator	5	9	39	60	6	24	79.5	0.8	1.6	4	14.4	0.0161	0.0786	0.0161	0.00034
			Mixer/Loader	3	5	39	60	6	24	79.5	0.8	1.6	2.4	8	0.0376	0.22	0.0376	0.000291
			Applicator/Mixer/Loader (g)	5	9	39	60	6	24	79.5	0.8	1.6	4	14.4	0.0537	0.2986	0.0537	0.000631
	Truck Mount	Spot	Applicator	6	10	60	90	7	30	79.5	0.38	1	2.28	10	1.3	0.39	1.3	0.0039
			Mixer/Loader	4	8	60	90	7	30	79.5	0.38	1	1.52	8	0.0376	0.22	0.0376	0.000291
			Applicator/Mixer/Loader (g)	6	10	60	90	7	30	79.5	0.38	1	2.28	10	1.3376	0.61	1.3376	0.004191
		Boom/Broadcast	Applicator	5	8	49	74	6	19	79.5	1.5	2.25	7.5	18	0.0161	0.0786	0.0161	0.00034
			Mixer/Loader	3	6	49	74	6	19	79.5	1.5	2.25	4.5	13.5	0.0376	0.22	0.0376	0.000291
			Applicator/Mixer/Loader (g)	5	8	49	74	6	19	79.5	1.5	2.25	7.5	18	0.0537	0.2986	0.0537	0.000631
Aquatic (Granular)	Boat	Spot	Applicator/Mixer/Loader	4	6	12	19	6	23	79.5	0.75	1.5	3	9	0.0069	0.0084	0.0069	0.0017
		Boom/Broadcast	Applicator/Mixer/Loader	4	6	12	19	6	23	79.5	1	2	4	12	0.0069	0.0084	0.0069	0.0017
Aquatic (Liquid)	Boat	Spot	Applicator	4	6	12	19	6	23	79.5	0.63	2	2.52	12	1.3	0.39	1.3	0.0039
			Mixer/Loader	1	2	3	4	6	23	79.5	0.63	2	0.63	4	0.0376	0.22	0.0376	0.000291
			Applicator/Mixer/Loader (g)	4	6	12	19	6	23	79.5	0.63	2	2.52	12	1.3376	0.61	1.3376	0.004191
		Boom/Broadcast	Applicator	4	6	12	19	6	23	79.5	1.3	3	5.2	18	0.0161	0.0786	0.0161	0.00034
			Mixer/Loader	1	2	3	4	6	23	79.5	1.3	3	1.3	6	0.0376	0.22	0.0376	0.000291
			Applicator/Mixer/Loader (g)	4	6	12	19	6	23	79.5	1.3	3	5.2	18	0.0537	0.2986	0.0537	0.000631

a.i.- Active ingredient.
ATV - All-Terrain Vehicle.
UTV - Utility Vehicle.
NA - Not Applicable.
(a) - With the exception of body weight, exposure parameters were provided by BLM personnel familiar with herbicide use in the vegetation treatment program.
(b) - See Table 4-2 for references. Values are expressed in terms of active ingredient, which for this purpose is the same as acid equivalent.2
(c) - USEPA 2012a. Standard Operating Procedures for Residential Pesticide Exposure Assessment. Mean body weight for adult males and females (age 16 to 80).
(d) - Information provided by BLM personnel familiar with herbicide use in the vegetation treatment program; see Table 4-1.
(e) - Acres treated per hour * hours per day.
(f) - All receptors are assumed to wear gloves with the exception of pilots, per BLM policy.
(g) - Sum of Applicator and Mixer Loader unit exposures.

Table 4-3
Occupational Pesticide Handler Unit Exposure Values

Dermal UE			
Long-Sleeve Shirt, Long Pants, Gloves (mg/lb a.i.)	**Long-Sleeve Shirt, Long Pants, No Gloves (mg/lb a.i.)**	**Inhalation UE (mg/lb a.i.)**	**Reference**
Mixing/Loading Liquids			
0.0376	0.22	0.000291	USEPA 2012. Mixing/loading liquids.
Mixing/Loading Dry Flowable			
0.0516	0.227	0.00896	USEPA 2012. Mixing/loading dry flowable.
Mixing/Loading Granular (Aquatic)			
0.0069	0.0084	0.0017	USEPA 2012. Mixing/loading granules.
Pilot			
Not provided	0.005	0.000068	USEPA 2012. Applicator, aerial, fixed wing (a).
Applicator, Open Cab Groundboom			
0.0161	0.0786	0.00034	USEPA 2012. Applicator, open cab groundboom.
Mixer/Loader/Applicator, Backpack Sprayer			
8.26	8.26	0.00258	USEPA 2012. Mixer/loader/applicator, backpack sprayer. General broadcast/foliar applications. Wildlife management, rights-of-way, forestry, landscaping, outdoor residential areas, aquatic areas (b).
Rights-of-way			
1.3	0.39	0.0039	USEPA 1998a. Scenario 24, rights-of-way sprayer application. Consists of unrolling hose, using spray gun then rolling it back up (c).

a.i. - active ingredient.
UE - Unit Exposure.
USEPA 1998. Pesticide Handler Exposure Database (PHED) Surrogate Exposure Guide. August 1998.
USEPA 2012b. Occupational Pesticide Handler Unit Exposure Surrogate Reference Guide. Values for single layer, no respirator.
(a) - Values provided for fixed wing aircraft only, and are therefore applied to both fixed wing and rotary aircraft.
(b) - Recommended for use in both the backpack and horseback scenarios (J. Evans, USEPA Office of Pesticide Programs (OPP) personal communication, 3/19/12).
(c) - USEPA 2012b does not provide a value for this scenario. Therefore, USEPA 1998 values were recommended for vehicle spot treatments (J. Evans, USEPA OPP personal communication, 3/20/12).

Table 4-4
Routine Use and Accidental Exposure Scenarios for Public Receptors

Receptor	Pathway	Scenario	Herbicide Concentration	Aminopyralid	Clopyralid	2,4-D					Fluroxypyr	Rimsulfuron
						Land (Annual/ Perennial)	Land (Woody Species)	Aquatic (Floating/ Emerged)	Aquatic (Submerged/ Volume)	Aquatic (Submerged/ Bottom)		
Hiker/Hunter - Adult	Dermal Contact with Spray	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray	x	x	x	x	x	x		x	x
	Dermal Contact with Foliage	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray	x	x	x	x	x	x		x	x
	Occasional Ingestion of Drinking Water	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray/Spill	x	x	x	x	x	x	x	x	x
Berry Picker - Child and Adult	Dermal Contact with Spray	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray	x	x	x	x	x	x		x	x
	Dermal Contact with Foliage	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray	x	x	x	x	x	x		x	x
	Occasional Ingestion of Drinking Water	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray/Spill	x	x	x	x	x	x	x	x	x
	Ingestion of Berries	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray	x	x	x	x	x	x		x	x
Angler - Adult	Dermal Contact with Spray	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray	x	x	x	x	x	x		x	x
	Dermal Contact with Foliage	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray	x	x	x	x	x	x		x	x
	Occasional Ingestion of Drinking Water	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray/Spill	x	x	x	x	x	x	x	x	x
	Ingestion of Fish	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray/Spill	x	x	x	x	x	x	x	x	x
Swimmer - Child and Adult	Dermal Contact with Water While Swimming	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray/Spill	x	x	x	x	x	x	x	x	x
	Ingestion of Water While Swimming	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray/Spill	x	x	x	x	x	x	x	x	x
Nearby Resident - Child and Adult	Dermal Contact with Spray	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray	x	x	x	x	x	x		x	x
	Dermal Contact with Foliage (Lawn)	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray	x	x	x	x	x	x		x	x
Native American - Child and Adult	Dermal Contact with Spray	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray	x	x	x	x	x	x		x	x
	Dermal Contact with Foliage	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray	x	x	x	x	x	x		x	x
	Dermal Contact with Water While Swimming	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray/Spill	x	x	x	x	x	x	x	x	x
	Occasional Ingestion of Drinking Water	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray/Spill	x	x	x	x	x	x	x	x	x
	Ingestion of Berries	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray	x	x	x	x	x	x		x	x
	Ingestion of Fish	Routine Use	Spray Drift	x	x	x	x	x	x		x	x
		Accidental	Direct Spray/Spill	x	x	x	x	x	x	x	x	x

Routine Use and Accidental Exposure Scenarios for Public Receptors

Receptor	Pathway	Scenario	Herbicide Concentration	Proposed Herbicide: Application via Air or Ground Methods	Proposed Herbicide: Application via Boat only, Granular product
Hiker/Hunter - Adult	Dermal Contact with Spray	Routine Use	Spray Drift	x	
		Accidental	Direct Spray	x	
	Dermal Contact with Foliage	Routine Use	Spray Drift	x	
		Accidental	Direct Spray	x	
	Occasional Ingestion of Drinking Water	Routine Use	Spray Drift	x	
		Accidental	Direct Spray/Spill	x	x
Berry Picker - Child and Adult	Dermal Contact with Spray	Routine Use	Spray Drift	x	
		Accidental	Direct Spray	x	
	Dermal Contact with Foliage	Routine Use	Spray Drift	x	
		Accidental	Direct Spray	x	
	Occasional Ingestion of Drinking Water	Routine Use	Spray Drift	x	
		Accidental	Direct Spray/Spill	x	x
	Ingestion of Berries	Routine Use	Spray Drift	x	
		Accidental	Direct Spray	x	
Angler - Adult	Dermal Contact with Spray	Routine Use	Spray Drift	x	
		Accidental	Direct Spray	x	
	Dermal Contact with Foliage	Routine Use	Spray Drift	x	
		Accidental	Direct Spray	x	
	Occasional Ingestion of Drinking Water	Routine Use	Spray Drift	x	
		Accidental	Direct Spray/Spill	x	x
	Ingestion of Fish	Routine Use	Spray Drift	x	
		Accidental	Direct Spray/Spill	x	x
Swimmer - Child and Adult	Dermal Contact with Water While Swimming	Routine Use	Spray Drift	x	
		Accidental	Direct Spray/Spill	x	x
	Ingestion of Water While Swimming	Routine Use	Spray Drift	x	
		Accidental	Direct Spray/Spill	x	x
Nearby Resident - Child and Adult	Dermal Contact with Spray	Routine Use	Spray Drift	x	
		Accidental	Direct Spray	x	
	Dermal Contact with Foliage (Lawn)	Routine Use	Spray Drift	x	
		Accidental	Direct Spray	x	
Native American - Child and Adult	Dermal Contact with Spray	Routine Use	Spray Drift	x	
		Accidental	Direct Spray	x	
	Dermal Contact with Foliage	Routine Use	Spray Drift	x	
		Accidental	Direct Spray	x	
	Dermal Contact with Water While Swimming	Routine Use	Spray Drift	x	
		Accidental	Direct Spray/Spill	x	x
	Occasional Ingestion of Drinking Water	Routine Use	Spray Drift	x	
		Accidental	Direct Spray/Spill	x	x
	Ingestion of Berries	Routine Use	Spray Drift	x	
		Accidental	Direct Spray	x	
	Ingestion of Fish	Routine Use	Spray Drift	x	
		Accidental	Direct Spray/Spill	x	x

Table 4-5
Exposure Parameters for Public Receptors

Pathway Parameter	Units	Hiker/Hunter - Adult	Berry Picker - Child (0-6 years)	Berry Picker - Adult	Angler - Adult	Swimmer- Child (0-6 years)	Swimmer - Adult	Nearby Resident - Child (0-6 years)	Nearby Resident - Adult	Native American- Child (0-6 years)	Native American- Adult
Dermal Contact - Spray Drift (Routine/Worst Case) and Direct Spray (Accident)											
Skin Exposed	cm^2/day	5,700 (a)	2,800 (a)	5,700 (a)	5,700 (a)	NA	NA	2,800 (a)	5,700 (a)	2,800 (a)	5,700 (a)
Body Weight	kg	79.5 (b)	15 (b)	79.5 (b)	79.5 (b)	NA	NA	15 (b)	79.5 (b)	15 (b)	79.5 (b)
Exposure Factor	cm^2/kg-day	71.70 (c)	186.67 (c)	71.70 (c)	71.70 (c)	NA	NA	186.67 (c)	71.70 (c)	186.67 (c)	71.70 (c)
Dermal Contact with Lawn (Nearby Resident) or Foliage (Hiker/Hunter, Berry Picker, Angler, Native American)											
Dermal Transfer Coefficient	cm^2/hour	640 (d)	363 (e)	1,100 (e)	640 (d)	NA	NA	59,400 (f)	180,000 (f)	363 (e)	1,100 (e)
Body Weight	kg	79.5 (b)	15 (b)	79.5 (b)	79.5 (b)	NA	NA	15 (b)	79.5 (b)	15 (b)	79.5 (b)
Exposure Time	hours/day	2.5 (g)	2.5 (g)	2.5 (g)	2.5 (g)	NA	NA	1.5 (f)	1.5 (f)	3 (h)	3 (h)
Exposure Factor	cm^2/kg-day	20.13 (i)	60.50 (i)	34.59 (i)	20.13 (i)	NA	NA	5,940.00 (i)	3,396.23 (i)	72.60 (i)	41.51 (i)
Dermal Contact with Water While Swimming											
Skin Exposed	cm^2	NA	NA	NA	NA	6,600 (j)	18,000 (j)	NA	NA	6,600 (j)	18,000 (j)
Exposure Time	hours/day	NA	NA	NA	NA	1 (k)	1 (k)	NA	NA	2.6 (l)	2.6 (l)
Body Weight	kg	NA	NA	NA	NA	15 (b)	79.5 (b)	NA	NA	15 (b)	79.5 (b)
Exposure Factor	cm^2-hr/kg-day	NA	NA	NA	NA	440.00 (m)	226.42 (m)	NA	NA	1144.00 (m)	588.68 (m)
Ingestion - Drinking Water (Hiker/Hunter, Berry Picker, Angler, Native American) and Swimming Water (Swimmer)											
Ingestion Rate	L/day	2 (n)	1 (n)	2 (n)	2 (n)	0.12 (o)	0.071 (o)	NA	NA	0.5 (h,p)	1 (h,p)
Body Weight	kg	79.5 (b)	15 (b)	79.5 (b)	79.5 (b)	15 (b)	79.5 (b)	NA	NA	15 (b)	79.5 (b)
Exposure Factor	L/kg-day	0.025157 (q)	0.066667 (q)	0.025157 (q)	0.025157 (q)	0.008 (q)	0.000893 (q)	NA	NA	0.033333 (q)	0.012579 (q)
Ingestion - Berries											
Ingestion Rate	mg/day	NA	60,000 (h,r)	320,000 (h,r)	NA	NA	NA	NA	NA	60,000 (h,r)	320,000 (h,r)
Ingestion Rate (converted)	cm^2/day	NA	60 (s)	320 (s)	NA	NA	NA	NA	NA	60 (s)	320 (s)
Body Weight	kg	NA	15 (b)	79.5 (b)	NA	NA	NA	NA	NA	15 (b)	79.5 (b)
Exposure Factor	cm^2/kg-day	NA	4.00 (q)	4.03 (q)	NA	NA	NA	NA	NA	4.00 (q)	4.03 (q)
Ingestion - Fish											
Ingestion Rate	mg/day	NA	NA	NA	61,000 (t)	NA	NA	NA	NA	167,000 (h,u)	885,000 (h,u)
Body Weight	kg	NA	NA	NA	79.5 (b)	NA	NA	NA	NA	15 (b)	79.5 (b)
Exposure Factor	mg/kg-day	NA	NA	NA	767.30 (q)	NA	NA	NA	NA	11,133.33 (q)	11,132.08 (q)

NA - Not Applicable. Receptor not assumed to be exposed to herbicides via this pathway.
(a) - USEPA 2004. Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual. Part E. July 2004. Exhibit 3-5. For the adult, the heads, hands, forearms, and lower legs are assumed to be exposed. For the child, the head, hands, forearms, lower legs, and feet are assumed to be exposed.
(b) - USEPA 2012a. Standard Operating Procedures for Residential Pesticide Exposure Assessment. For adults, mean body weight for adult males and females (age 16 to 80). For children, a weighted average was calculated based on data for children aged 6 months to 6 years ([1 year * 9.2 kg + 1 year * 11.4 kg + 1 year * 13.8 kg + 3 years * 18.6 kg]/6 years).
(c) - Skin Exposed / Body Weight.
(d) - USEPA 2011b. Science Advisory Council for Exposure Policy 3. Value for scouting grapes used as surrogate for walking/hiking through brush.
(e) - USEPA 2011b. Science Advisory Council for Exposure Policy 3. Value for harvesting lowbush blueberries. The child value was obtained by multiplying the adult value by a transfer coefficient surface area adjustment factor of 0.33, which was calculated based on data presented in USEPA 2012 for children aged 6 months to 6 years ([1 year * 0.23 + 1 year * 0.27 + 1 year * 0.31 + 3 years * 0.39]/6 years).
(f) - USEPA 2012a. Standard Operating Procedures for Residential Pesticide Exposure Assessment, Table 3-3. Transfer coefficient and fraction application rate available for liquids, wettable powders, and water dispersible granules. The child transfer coefficient was obtained by multiplying the adult transfer coefficient by a surface area adjustment factor of 0.33, which was calculated based on data for children aged 6 months to 6 years ([1 year * 0.23 + 1 year * 0.27 + 1 year * 0.31 + 3 years * 0.39]/6 years). Exposure time for adults and children is based on time spent at home in the yard or other areas outside the house.
(g) - USEPA 2011a. Exposure Factors Handbook. Mean value for time spent outdoors away from residence, all ages (154 minutes/day) (USEPA 2011a, Table 16-20).
(h) - Harper et al. 2002. The Spokane Tribe's Multipathway Subsistence Exposure Scenario and Screening Level RME. Risk Analysis. 22(3):513-526.
(i) - Dermal Transfer Coefficient x Exposure Time / Body Weight.
(j) - USEPA 2004. Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual. Part E. July 2004. Exhibit 3-2.
(k) - USEPA 2011a. Exposure Factors Handbook, Table ES-1 presents a range of data for swimming exposure times for adults and children. The 95th percentile estimate for adults and children is 181 minutes/month. It is assumed that 1/3 of this time is on BLM lands (60 minutes).
(l) - Harris and Harper 1997. A Native American Exposure Scenario. Risk Analysis: 17(6):789-795.
(m) - (Skin Exposed x Exposure Time) / Body Weight.
(n) - USEPA 1991. Standard Default Exposure Factors.
(o) - USEPA 2011a. Exposure Factors Handbook, Table ES-1. 95th percentile hourly rate for adults (71 mL/hour) and children (120 mL/hour) multiplied by swimming exposure time (1 hour per day).
(p) - One liter of water is ingested away from home, which is assumed to be from the surface water source. The child ingestion rate is assumed to be 1/2 of the adult ingestion rate.
(q) - Ingestion Rate/Body Weight.
(r) - The amount of ingested gathered terrestrial above ground vegetation is 320 g/day for adults (20% of 1600 g/day of total vegetal intake, per Harper et al., 2002). The child ingestion rate is calculated as a ratio of the body weights (320 g/day x 15 kg/79.5 kg).
(s) - Weight to surface area conversion for berry ingestion: Ingestion rate (mg/day) * 1 g/1000 mg * 2 cm^2/g. Assume that 1/2 of berry has herbicide residue, so value is multiplied by 0.5.
(t) - USEPA 2011a. Exposure Factors Handbook, Table 10-5 - highest 95th percentile recreational fish ingestion rate listed, based on an Indiana survey. Note that a slightly higher mean value is presented; however, the value is based on fishing in the Savannah River in Georgia, which is not relevant to fishing in ponds in the west.
(u) - The fish consumption rate for an adult for a high fish diet is 885 g/day. The child ingestion rate is calculated as a ratio of the body weights (885 g/day x 15 kg/79.5 kg).

Table 4-6
Calculation of Exposure Point Concentrations - Active Ingredient in a Spill to Worker Skin - Concentrated Solution

Herbicide	Concentrated Liquid: Concentration		Concentrated Liquid: Units	EPC: Spill EPC (d)	EPC: Units
Aminopyralid	2	(a)	lb a.e./gallon	240,000	mg a.e./L
Clopyralid	3	(a)	lb a.e./gallon	360,000	mg a.e./L
2,4-D (Land - Annual/Perennial)	5.5	(a)	lb a.e./gallon	660,000	mg a.e./L
2,4-D (Land - Woody Species)	5.5	(a)	lb a.e./gallon	660,000	mg a.e./L
2,4-D (Aquatic - Floating and Emerged)	3.8	(a)	lb a.e./gallon	456,000	mg a.e./L
2,4-D (Aquatic - Submerged; liquid)	3.8	(a)	lb a.e./gallon	456,000	mg a.e./L
2,4-D (Aquatic - Submerged; granular)	NA	(b)	NA	NA	NA
Fluroxypyr	2.8	(a)	lb a.e./gallon	336,000	mg a.e./L
Rimsulfuron	0.0125	(c)	lb a.i./gallon	1,500	mg a.i./L

a.e. - acid equivalent.
a.i. - active ingredient.
EPC - Exposure Point Concentration.
Not Applicable.
(a) - Concentrated liquid concentration from label, prior to mixing to achieve desired application concentration. Highest concentration in products used was selected as a worst-case estimate of potential spill concentration.
(b) - This product is applied via boat and is granular; therefore, there is no liquid concentrate or solution and therefore this pathway is not evaluated for the granular product.
(c) - Product is granular or dry flowable. Concentration in spill calculated as follows:
EPC in Spill = Maximum Application Rate (0.0625 lb a.i./acre) / Lowest Spray Rate (5 gallons/acre) = 0.0125 lbs a.i./acre.
(d) - Converted from (a) : lb [a.e. or a.i.]/gallon * 453,600 mg/lb * 1 gallon/3.78 L.

Table 4-7
Calculation of Exposure Point Concentrations - Active Ingredient in a Spill to Worker Skin - Mixed Solution

Herbicide (a)	Application Scenario	Application Rate (b) (lb a.e./acre)	Lowest Spray Rate (gal/acre)	Concentration in Mix (c) (lb a.e./gallon)	Spill EPC (d) (mg a.e./L)
2,4-D (Land - Annual/Perennial)	Maximum	2	5	0.4	48,000
2,4-D (Land - Annual/Perennial)	Typical	1	5	0.2	24,000
2,4-D (Land - Woody Species)	Maximum	4	5	0.8	96,000
2,4-D (Land - Woody Species)	Typical	2	5	0.4	48,000
2,4-D (Aquatic - Floating and Emerged)	Maximum	4	5	0.8	96,000
2,4-D (Aquatic - Floating and Emerged)	Typical	2	5	0.4	48,000
2,4-D (Aquatic - Submerged; liquid)	Maximum	10.8	5	2.2	259,200
2,4-D (Aquatic - Submerged; liquid)	Typical	5.4	5	1.1	129,600
Rimsulfuron	Typical	0.0469	5	0.00938	1,126

a.e. - acid equivalent.
EPC - Exposure Point Concentration.
(a) - Aggregate Risk Indices (ARI) for 2,4-D under the concentrated solution scenario are below one (See Section 5). Therefore, a mixed solution scenario is also evaluate
The ARI for a mixed solution assuming the maximum application rate is also below one (See Section 5). Therefore, a mixed solution assuming the typical application rate is also evaluated. ARI for rimsulfuron under the maximum application rate scenario is below one, therefore a mixed solution assuming the typical application rate is also evalauted.
(b) - See Table 4-1.
(c) - Calculated as follows:
Spill EPC = Application Rate (lb [a.i. or a.e.]/acre) / Lowest Spray Rate (gallons/acre).
Lowest Spray Rate = 5 gallons/acre from a helicopter (5 gallons/acre-feet for 2,4-D Aquatic, submerged liquid).
(d) - Converted from (c): lb [a.e. or a.i.]/gallon * 453,600 mg/lb * 1 gallon/3.78 L.

Table 4-8
Spray Drift Deposition Rates

AgDRIFT® Scenario (a)	Land Type (b)	Equipment	Application Rate Scenario (c)	Aminopyralid (mg a.e./cm²)	Clopyralid (mg a.e./cm²)	2,4-D (d) Land (Annual/Perennial) (mg a.e./cm²)	2,4-D (d) Land (Woody Species) (mg a.e./cm²)	2,4-D (d) Aquatic (Floating/Emerged) (mg a.e./cm²)	2,4-D (d) Aquatic (Submerged/ Volume) (e) (mg a.e./cm²)	Fluroxypyr (mg a.e./cm²)	Rimsulfuron (f) (mg a.i./cm²)
Aerial	Non-Forested	Plane	Typical	3.36E-05	4.03E-05	2.03E-04	4.50E-04	4.50E-04	1.29E-03	4.14E-05	1.90E-05
Aerial	Non-Forested	Helicopter	Typical	2.80E-05	3.36E-05	1.66E-04	3.61E-04	3.61E-04	1.05E-03	3.47E-05	1.57E-05
Aerial	Forested	Plane	Typical	7.84E-05	9.52E-05	3.89E-04	7.90E-04	NA	NA	1.87E-04	8.06E-05
Aerial	Forested	Helicopter	Typical	4.48E-06	5.60E-06	2.13E-05	4.03E-05	NA	NA	1.46E-05	6.72E-06
Ground	Not applicable (g)	Low Boom (h)	Typical	3.36E-06	1.23E-05	5.04E-05	1.01E-04	1.01E-04	2.71E-04	1.34E-05	2.24E-06
Ground	Not applicable (g)	High Boom (h)	Typical	6.72E-06	2.02E-05	7.95E-05	1.59E-04	1.59E-04	4.29E-04	2.02E-05	3.36E-06
Aerial	Non-Forested	Plane	Maximum	5.04E-05	9.30E-05	4.50E-04	9.56E-04	9.56E-04	2.44E-03	9.30E-05	2.69E-05
Aerial	Non-Forested	Helicopter	Maximum	4.14E-05	7.39E-05	3.61E-04	7.76E-04	7.76E-04	1.92E-03	7.39E-05	2.13E-05
Aerial	Forested	Plane	Maximum	1.11E-04	1.93E-04	7.90E-04	1.63E-03	NA	NA	3.77E-04	1.02E-04
Aerial	Forested	Helicopter	Maximum	5.60E-06	1.12E-05	4.03E-05	8.06E-05	NA	NA	2.91E-05	8.96E-06
Ground	Not applicable (g)	Low Boom (h)	Maximum	5.60E-06	2.46E-05	1.01E-04	2.00E-04	2.00E-04	5.43E-04	2.46E-05	3.36E-06
Ground	Not applicable (g)	High Boom (h)	Maximum	8.96E-06	3.92E-05	1.59E-04	3.18E-04	3.18E-04	8.58E-04	3.92E-05	1.46E-05

a.e. - acid equivalent.
a.i. - active ingredient.
NA. Not Applicable. Deposition on a pond is simulated using the non-forested land type option.
(a) - Deposition rates were calculated using AgDRIFT® software. Several deposition rates assuming different distances to receptor were calculated to support the ecological risk assessment. For the human health risk assessment, the deposition rates based on the closest distance to receptor (e.g., 100 feet for aerial applications and 25 feet for ground applications) were selected.
(b) - Land type selected in AgDRIFT® to calculate deposition rates for aerial scenarios using the Tier II version of the model.
(c) - See Table 4-1.
(d) - Deposition rates were derived for three of the four 2,4-D application scenarios; deposition rates were not derived for the scenario involving granular application via boat. See Table 4-1. For the aquatic applications, it is assumed that spray drift settles onto an adjacent pond that was not targeted for spraying.
(e) - Deposition rates for spray drift from this herbicide were calculated assuming a pond size of 1 acre and 1 foot, as the application rates for this formulation are in lb a.e./acre-foot.
(f) - Typical application rate scenario is applicable to rangeland and public-domain forest land. Maximum application rate scenario is applicable to all five land programs.
(g) - Land type not applicable to ground applications, which are evaluated using the Tier I version of the model.
(h) - Boom/Broadcast applications (see Table 4-1) can be conducted using low or high booms, which are evaluated separately here as boom height affects the deposition rate of off-site drift.

Table 4-9
Pond Exposure Point Concentrations Due to Spray Drift

AgDRIFT® Scenario (a)	Land Type (b)	Equipment	Application Rate Scenario (c)	Aminopyralid (mg a.e./L)	Clopyralid (mg a.e./L)	2,4-D (d)				Fluroxypyr (mg a.e./L)	Rimsulfuron (f) (mg a.i./L)
						Land (Annual/ Perennial) (mg a.e./L)	Land (Woody Species) (mg a.e./L)	Aquatic (Floating/Emerged) (mg a.e./L)	Aquatic (Submerged/ Volume) (e) (mg a.e./L)		
Aerial	Non-Forested	Plane	Typical	4.30E-04	5.20E-04	2.56E-03	5.60E-03	5.60E-03	1.62E-02	5.44E-04	2.47E-04
Aerial	Non-Forested	Helicopter	Typical	3.60E-04	4.39E-04	2.13E-03	4.56E-03	4.56E-03	1.34E-02	3.27E-03	2.03E-04
Aerial	Forested	Plane	Typical	9.78E-04	1.23E-03	5.00E-03	1.01E-02	NA	NA	1.27E-03	5.70E-04
Aerial	Forested	Helicopter	Typical	5.76E-05	7.41E-05	2.96E-04	5.55E-04	NA	NA	7.53E-05	3.36E-05
Ground	Not applicable (g)	Low Boom (h)	Typical	5.32E-05	1.70E-04	6.82E-04	1.36E-03	1.36E-03	3.68E-03	1.77E-04	3.20E-05
Ground	Not applicable (g)	High Boom (h)	Typical	8.54E-05	2.74E-04	1.09E-03	2.19E-03	2.19E-03	5.91E-03	2.85E-04	5.13E-05
Aerial	Non-Forested	Plane	Maximum	6.36E-04	1.19E-03	5.60E-03	1.19E-02	1.19E-02	3.15E-02	1.18E-03	3.38E-04
Aerial	Non-Forested	Helicopter	Maximum	5.26E-04	9.72E-04	4.56E-03	9.84E-03	9.84E-03	2.59E-02	9.72E-04	2.75E-04
Aerial	Forested	Plane	Maximum	1.39E-03	2.48E-03	1.01E-02	2.07E-02	NA	NA	2.57E-03	7.22E-04
Aerial	Forested	Helicopter	Maximum	8.01E-05	1.52E-04	5.55E-04	1.15E-03	NA	NA	1.52E-04	4.30E-05
Ground	Not Applicable (g)	Low Boom (h)	Maximum	7.50E-05	3.41E-04	1.36E-03	2.73E-03	2.73E-03	7.36E-03	3.41E-04	4.26E-05
Ground	Not Applicable (g)	High Boom (h)	Maximum	1.20E-04	5.47E-04	2.10E-02	4.38E-03	4.38E-03	1.18E-02	5.47E-04	6.84E-05

a.e. - acid equivalent.

a.i. - active ingredient.

NA - Not Applicable. Deposition on a pond is simulated using the non-forested land type option.

(a) - Pond concentrations were calculated using AgDRIFT® software. Several deposition rates assuming different distances to receptor were calculated to support the ecological risk assessment. For the human health risk assessment, the deposition rates based on the closest distance to receptor were selected. For the human health risk assessment, the deposition rates based on the closest distance to receptor (e.g., 100 feet for aerial applications and 25 feet for ground applications) were selected.

(b) - Land type selected in AgDRIFT® to calculate deposition rates for aerial scenarios using the Tier II version of the model.

(c) - See Table 4-1.

(d) - Deposition rates were derived for three of the four 2,4-D application scenarios; deposition rates were not derived for the scenario involving granular application via boat. See Table 4-1. For the aquatic applications, it is assumed that spray drift settles onto an adjacent pond that was not targeted for spraying.

(e) - Deposition rates for spray drift from this herbicide were calculated assuming a pond size of 1 acre and 1 foot, as the application rates for this formulation are in lb a.e./acre-foot.

(f) - Typical application rate scenario is applicable to rangeland and public-domain forest land. Maximum application rate scenario is applicable to all five land programs.

(g) - Land type not applicable to ground applications, which are evaluated using the Tier I version of the model.

(h) - Boom/Broadcast applications (see Table 4-1) can be conducted using low or high booms, which are evaluated separately here as boom height affects the

Table 4-10
Pond Exposure Point Concentrations Due to Runoff off for Terrestrial Herbicides (a)

Averaging Time	Application Scenario	Exposure Scenario	Aminopyralid (mg a.e./L)	Clopyralid (mg a.e./L)	2,4-D (Land - Annual/Perennial) (b) (mg a.e./L)	2,4-D (Land - Woody Species) (b) (mg a.e./L)	Fluroxypyr (mg a.e./L)	Rimsulfuron (c) (mg a.i./L)
7-day	Typical	Short	6.51E-02	2.64E-02	7.02E-02	1.35E-01	2.71E-02	3.30E-03
7-day	Maximum	Short	9.19E-02	5.28E-02	1.40E-01	2.69E-01	5.21E-02	4.40E-03
30-day	Typical	Intermediate	6.35E-02	2.54E-02	4.71E-02	8.61E-02	1.80E-02	1.71E-03
30-day	Maximum	Intermediate	8.95E-02	5.08E-02	9.42E-02	1.72E-01	3.46E-02	2.27E-03
Annual	Typical	Long	4.50E-02	4.11E-03	5.11E-03	9.25E-03	2.17E-03	1.95E-04
Annual	Maximum	Long	6.34E-02	8.22E-03	1.02E-02	1.85E-02	4.18E-03	2.59E-04

a.e. - acid equivalent.
a.i. - active ingredient.
(a) - Pond concentrations were calculated using GLEAMS for a variety of scenarios (see text). The maximum pond concentration calculated for each averaging time (7-day, 30-day, and annual) was selected and presented here.
(b) - Runoff modeled only for terrestrial use of 2,4-D.
(c) - Typical application rate scenario is applicable to rangeland and public-domain forest land. Maximum application rate scenario is applicable to all five land programs.

Table 4-11
Calculation of Pond Exposure Point Concentrations Due to Spray Drift and Runoff for Terrestrial Herbicides

AgDRIFT® Scenario	Land Type (a)	Equipment	Application Rate Scenario (b)	Exposure Duration (c)	Aminopyralid			Clopyralid			2,4-D - Land (g): Annual/Perennial			2,4-D - Land (g): Woody Species		
					Spray Drift (d) (mg a.e./L)	Runoff (e) (mg a.e./L)	Total (f) (mg a.e./L)	Spray Drift (d) (mg a.e./L)	Runoff (e) (mg a.e./L)	Total (f) (mg a.e./L)	Spray Drift (d) (mg a.e./L)	Runoff (e) (mg a.e./L)	Total (f) (mg a.e./L)	Spray Drift (d) (mg a.e./L)	Runoff (e) (mg a.e./L)	Total (f) (mg a.e./L)
Aerial	Non-Forested	Plane	Typical	Short	4.30E-04	6.51E-02	6.56E-02	5.20E-04	2.64E-02	2.69E-02	2.56E-03	7.02E-02	7.27E-02	5.60E-03	1.35E-01	1.40E-01
Aerial	Non-Forested	Helicopter	Typical	Short	3.60E-04	6.51E-02	6.55E-02	4.39E-04	2.64E-02	2.68E-02	2.13E-03	7.02E-02	7.23E-02	4.56E-03	1.35E-01	1.39E-01
Aerial	Forested	Plane	Typical	Short	9.78E-04	6.51E-02	6.61E-02	1.23E-03	2.64E-02	2.76E-02	5.00E-03	7.02E-02	7.52E-02	1.01E-02	1.35E-01	1.45E-01
Aerial	Forested	Helicopter	Typical	Short	5.76E-05	6.51E-02	6.52E-02	7.41E-05	2.64E-02	2.65E-02	2.96E-04	7.02E-02	7.05E-02	5.55E-04	1.35E-01	1.35E-01
Ground	Not applicable (j)	Low Boom (k)	Typical	Short	5.32E-05	6.51E-02	6.52E-02	1.70E-04	2.64E-02	2.66E-02	6.82E-04	7.02E-02	7.08E-02	1.36E-03	1.35E-01	1.36E-01
Ground	Not applicable (j)	High Boom (k)	Typical	Short	8.54E-05	6.51E-02	6.52E-02	2.74E-04	2.64E-02	2.67E-02	1.09E-03	7.02E-02	7.13E-02	2.19E-03	1.35E-01	1.37E-01
Aerial	Non-Forested	Plane	Maximum	Short	6.36E-04	9.19E-02	9.25E-02	1.19E-03	5.28E-02	5.40E-02	5.60E-03	1.40E-01	1.46E-01	1.19E-02	2.69E-01	2.81E-01
Aerial	Non-Forested	Helicopter	Maximum	Short	5.26E-04	9.19E-02	9.24E-02	9.72E-04	5.28E-02	5.38E-02	4.56E-03	1.40E-01	1.45E-01	9.84E-03	2.69E-01	2.79E-01
Aerial	Forested	Plane	Maximum	Short	1.39E-03	9.19E-02	9.33E-02	2.48E-03	5.28E-02	5.53E-02	1.01E-02	1.40E-01	1.50E-01	2.07E-02	2.69E-01	2.90E-01
Aerial	Forested	Helicopter	Maximum	Short	8.01E-05	9.19E-02	9.20E-02	1.52E-04	5.28E-02	5.30E-02	5.55E-04	1.40E-01	1.41E-01	1.15E-03	2.69E-01	2.70E-01
Ground	Not applicable (j)	Low Boom (k)	Maximum	Short	7.50E-05	9.19E-02	9.19E-02	3.41E-04	5.28E-02	5.31E-02	1.36E-03	1.40E-01	1.42E-01	2.73E-03	2.69E-01	2.72E-01
Ground	Not applicable (j)	High Boom (k)	Maximum	Short	1.20E-04	9.19E-02	9.20E-02	5.47E-04	5.28E-02	5.33E-02	2.10E-02	1.40E-01	1.61E-01	4.38E-03	2.69E-01	2.74E-01
Aerial	Non-Forested	Plane	Typical	Intermediate	4.30E-04	6.35E-02	6.39E-02	5.20E-04	2.54E-02	2.59E-02	2.56E-03	4.71E-02	4.97E-02	5.60E-03	8.61E-02	9.17E-02
Aerial	Non-Forested	Helicopter	Typical	Intermediate	3.60E-04	6.35E-02	6.39E-02	4.39E-04	2.54E-02	2.58E-02	2.13E-03	4.71E-02	4.92E-02	4.56E-03	8.61E-02	9.07E-02
Aerial	Forested	Plane	Typical	Intermediate	9.78E-04	6.35E-02	6.45E-02	1.23E-03	2.54E-02	2.66E-02	5.00E-03	4.71E-02	5.21E-02	1.01E-02	8.61E-02	9.62E-02
Aerial	Forested	Helicopter	Typical	Intermediate	5.76E-05	6.35E-02	6.35E-02	7.41E-05	2.54E-02	2.54E-02	2.96E-04	4.71E-02	4.74E-02	5.55E-04	8.61E-02	8.67E-02
Ground	Not applicable (j)	Low Boom (k)	Typical	Intermediate	5.32E-05	6.35E-02	6.35E-02	1.70E-04	2.54E-02	2.55E-02	6.82E-04	4.71E-02	4.78E-02	1.36E-03	8.61E-02	8.75E-02
Ground	Not applicable (j)	High Boom (k)	Typical	Intermediate	8.54E-05	6.35E-02	6.36E-02	2.74E-04	2.54E-02	2.56E-02	1.09E-03	4.71E-02	4.82E-02	2.19E-03	8.61E-02	8.83E-02
Aerial	Non-Forested	Plane	Maximum	Intermediate	6.36E-04	8.95E-02	9.02E-02	1.19E-03	5.08E-02	5.19E-02	5.60E-03	9.42E-02	9.98E-02	1.19E-02	1.72E-01	1.84E-01
Aerial	Non-Forested	Helicopter	Maximum	Intermediate	5.26E-04	8.95E-02	9.01E-02	9.72E-04	5.08E-02	5.17E-02	4.56E-03	9.42E-02	9.88E-02	9.84E-03	1.72E-01	1.82E-01
Aerial	Forested	Plane	Maximum	Intermediate	1.39E-03	8.95E-02	9.09E-02	2.48E-03	5.08E-02	5.32E-02	1.01E-02	9.42E-02	1.04E-01	2.07E-02	1.72E-01	1.93E-01
Aerial	Forested	Helicopter	Maximum	Intermediate	8.01E-05	8.95E-02	8.96E-02	1.52E-04	5.08E-02	5.09E-02	5.55E-04	9.42E-02	9.48E-02	1.15E-03	1.72E-01	1.73E-01
Ground	Not applicable (j)	Low Boom (k)	Maximum	Intermediate	7.50E-05	8.95E-02	8.96E-02	3.41E-04	5.08E-02	5.11E-02	1.36E-03	9.42E-02	9.56E-02	2.73E-03	1.72E-01	1.75E-01
Ground	Not applicable (j)	High Boom (k)	Maximum	Intermediate	1.20E-04	8.95E-02	8.97E-02	5.47E-04	5.08E-02	5.13E-02	2.10E-02	9.42E-02	1.15E-01	4.38E-03	1.72E-01	1.77E-01
Aerial	Non-Forested	Plane	Typical	Long	4.30E-04	4.50E-02	4.54E-02	5.20E-04	4.11E-03	4.63E-03	2.56E-03	5.11E-03	7.67E-03	5.60E-03	9.25E-03	1.48E-02
Aerial	Non-Forested	Helicopter	Typical	Long	3.60E-04	4.50E-02	4.54E-02	4.39E-04	4.11E-03	4.55E-03	2.13E-03	5.11E-03	7.24E-03	4.56E-03	9.25E-03	1.38E-02
Aerial	Forested	Plane	Typical	Long	9.78E-04	4.50E-02	4.60E-02	1.23E-03	4.11E-03	5.34E-03	5.00E-03	5.11E-03	1.01E-02	1.01E-02	9.25E-03	1.93E-02
Aerial	Forested	Helicopter	Typical	Long	5.76E-05	4.50E-02	4.50E-02	7.41E-05	4.11E-03	4.18E-03	2.96E-04	5.11E-03	5.40E-03	5.55E-04	9.25E-03	9.80E-03
Ground	Not applicable (j)	Low Boom (k)	Typical	Long	5.32E-05	4.50E-02	4.50E-02	1.70E-04	4.11E-03	4.28E-03	6.82E-04	5.11E-03	5.79E-03	1.36E-03	9.25E-03	1.06E-02
Ground	Not applicable (j)	High Boom (k)	Typical	Long	8.54E-05	4.50E-02	4.51E-02	2.74E-04	4.11E-03	4.38E-03	1.09E-03	5.11E-03	6.20E-03	2.19E-03	9.25E-03	1.14E-02
Aerial	Non-Forested	Plane	Maximum	Long	6.36E-04	6.34E-02	6.41E-02	1.19E-03	8.22E-03	9.41E-03	5.60E-03	1.02E-02	1.58E-02	1.19E-02	1.85E-02	3.04E-02
Aerial	Non-Forested	Helicopter	Maximum	Long	5.26E-04	6.34E-02	6.40E-02	9.72E-04	8.22E-03	9.19E-03	4.56E-03	1.02E-02	1.48E-02	9.84E-03	1.85E-02	2.83E-02
Aerial	Forested	Plane	Maximum	Long	1.39E-03	6.34E-02	6.48E-02	2.48E-03	8.22E-03	1.07E-02	1.01E-02	1.02E-02	2.03E-02	2.07E-02	1.85E-02	3.92E-02
Aerial	Forested	Helicopter	Maximum	Long	8.01E-05	6.34E-02	6.35E-02	1.52E-04	8.22E-03	8.37E-03	5.55E-04	1.02E-02	1.08E-02	1.15E-03	1.85E-02	1.96E-02
Ground	Not applicable (j)	Low Boom (k)	Maximum	Long	7.50E-05	6.34E-02	6.35E-02	3.41E-04	8.22E-03	8.56E-03	1.36E-03	1.02E-02	1.16E-02	2.73E-03	1.85E-02	2.12E-02
Ground	Not applicable (j)	High Boom (k)	Maximum	Long	1.20E-04	6.34E-02	6.36E-02	5.47E-04	8.22E-03	8.76E-03	2.10E-02	1.02E-02	3.12E-02	4.38E-03	1.85E-02	2.29E-02

Table 4-11
Calculation of Pond Exposure Point Concentrations Due to Spray Drift and I

					2,4-D - Aquatic (g)											
			Application		Floating/Emerged			Submerged (Volume of Water)			Fluroxypyr			Rimsulfuron (i)		
AgDRIFT® Scenario	Land Type (a)	Equipment	Rate Scenario (b)	Exposure Duration (c)	Spray Drift (d) (mg a.e./L)	Runoff (e) (mg a.e./L)	Total (f) (mg a.e./L)	Spray Drift (d,h) (mg a.e./L)	Runoff (e) (mg a.e./L)	Total (f) (mg a.e./L)	Spray Drift (d) (mg a.e./L)	Runoff (e) (mg a.e./L)	Total (f) (mg a.e./L)	Spray Drift (d) (mg a.i./L)	Runoff (e) (mg a.i./L)	Total (f) (mg a.i./L)
Aerial	Non-Forested	Plane	Typical	Short	5.60E-03	(l)	5.60E-03	1.62E-02	(l)	1.62E-02	5.44E-04	2.71E-02	2.76E-02	2.47E-04	3.30E-03	3.55E-03
Aerial	Non-Forested	Helicopter	Typical	Short	4.56E-03	(l)	4.56E-03	1.34E-02	(l)	1.34E-02	3.27E-03	2.71E-02	3.04E-02	2.03E-04	3.30E-03	3.51E-03
Aerial	Forested	Plane	Typical	Short	NA	(l)	NA	NA	(l)	NA	1.27E-03	2.71E-02	2.84E-02	5.70E-04	3.30E-03	3.87E-03
Aerial	Forested	Helicopter	Typical	Short	NA	(l)	NA	NA	(l)	NA	7.53E-05	2.71E-02	2.72E-02	3.36E-05	3.30E-03	3.34E-03
Ground	Not applicable (j)	Low Boom (k)	Typical	Short	1.36E-03	(l)	1.36E-03	3.68E-03	(l)	3.68E-03	1.77E-04	2.71E-02	2.73E-02	3.20E-05	3.30E-03	3.34E-03
Ground	Not applicable (j)	High Boom (k)	Typical	Short	2.19E-03	(l)	2.19E-03	5.91E-03	(l)	5.91E-03	2.85E-04	2.71E-02	2.74E-02	5.13E-05	3.30E-03	3.35E-03
Aerial	Non-Forested	Plane	Maximum	Short	1.19E-02	(l)	1.19E-02	3.15E-02	(l)	3.15E-02	1.18E-03	5.21E-02	5.33E-02	3.38E-04	4.40E-03	4.74E-03
Aerial	Non-Forested	Helicopter	Maximum	Short	9.84E-03	(l)	9.84E-03	2.59E-02	(l)	2.59E-02	9.72E-04	5.21E-02	5.31E-02	2.75E-04	4.40E-03	4.68E-03
Aerial	Forested	Plane	Maximum	Short	NA	(l)	NA	NA	(l)	NA	2.57E-03	5.21E-02	5.47E-02	7.22E-04	4.40E-03	5.12E-03
Aerial	Forested	Helicopter	Maximum	Short	NA	(l)	NA	NA	(l)	NA	1.52E-04	5.21E-02	5.23E-02	4.30E-05	4.40E-03	4.44E-03
Ground	Not applicable (j)	Low Boom (k)	Maximum	Short	2.73E-03	(l)	2.73E-03	7.36E-03	(l)	7.36E-03	3.41E-04	5.21E-02	5.24E-02	4.26E-05	4.40E-03	4.44E-03
Ground	Not applicable (j)	High Boom (k)	Maximum	Short	4.38E-03	(l)	4.38E-03	1.18E-02	(l)	1.18E-02	5.47E-04	5.21E-02	5.26E-02	6.84E-05	4.40E-03	4.47E-03
Aerial	Non-Forested	Plane	Typical	Intermediate	5.60E-03	(l)	5.60E-03	1.62E-02	(l)	1.62E-02	5.44E-04	1.80E-02	1.86E-02	2.47E-04	1.71E-03	1.95E-03
Aerial	Non-Forested	Helicopter	Typical	Intermediate	4.56E-03	(l)	4.56E-03	1.34E-02	(l)	1.34E-02	3.27E-03	1.80E-02	2.13E-02	2.03E-04	1.71E-03	1.91E-03
Aerial	Forested	Plane	Typical	Intermediate	NA	(l)	NA	NA	(l)	NA	1.27E-03	1.80E-02	1.93E-02	5.70E-04	1.71E-03	2.28E-03
Aerial	Forested	Helicopter	Typical	Intermediate	NA	(l)	NA	NA	(l)	NA	7.53E-05	1.80E-02	1.81E-02	3.36E-05	1.71E-03	1.74E-03
Ground	Not applicable (j)	Low Boom (k)	Typical	Intermediate	1.36E-03	(l)	1.36E-03	3.68E-03	(l)	3.68E-03	1.77E-04	1.80E-02	1.82E-02	3.20E-05	1.71E-03	1.74E-03
Ground	Not applicable (j)	High Boom (k)	Typical	Intermediate	2.19E-03	(l)	2.19E-03	5.91E-03	(l)	5.91E-03	2.85E-04	1.80E-02	1.83E-02	5.13E-05	1.71E-03	1.76E-03
Aerial	Non-Forested	Plane	Maximum	Intermediate	1.19E-02	(l)	1.19E-02	3.15E-02	(l)	3.15E-02	1.18E-03	3.46E-02	3.58E-02	3.38E-04	2.27E-03	2.61E-03
Aerial	Non-Forested	Helicopter	Maximum	Intermediate	9.84E-03	(l)	9.84E-03	2.59E-02	(l)	2.59E-02	9.72E-04	3.46E-02	3.56E-02	2.75E-04	2.27E-03	2.55E-03
Aerial	Forested	Plane	Maximum	Intermediate	NA	(l)	NA	NA	(l)	NA	2.57E-03	3.46E-02	3.72E-02	7.22E-04	2.27E-03	2.99E-03
Aerial	Forested	Helicopter	Maximum	Intermediate	NA	(l)	NA	NA	(l)	NA	1.52E-04	3.46E-02	3.48E-02	4.30E-05	2.27E-03	2.32E-03
Ground	Not applicable (j)	Low Boom (k)	Maximum	Intermediate	2.73E-03	(l)	2.73E-03	7.36E-03	(l)	7.36E-03	3.41E-04	3.46E-02	3.50E-02	4.26E-05	2.27E-03	2.32E-03
Ground	Not applicable (j)	High Boom (k)	Maximum	Intermediate	4.38E-03	(l)	4.38E-03	1.18E-02	(l)	1.18E-02	5.47E-04	3.46E-02	3.52E-02	6.84E-05	2.27E-03	2.34E-03
Aerial	Non-Forested	Plane	Typical	Long	5.60E-03	(l)	5.60E-03	1.62E-02	(l)	1.62E-02	5.44E-04	2.17E-03	2.72E-03	2.47E-04	1.95E-04	4.42E-04
Aerial	Non-Forested	Helicopter	Typical	Long	4.56E-03	(l)	4.56E-03	1.34E-02	(l)	1.34E-02	3.27E-03	2.17E-03	5.44E-03	2.03E-04	1.95E-04	3.98E-04
Aerial	Forested	Plane	Typical	Long	NA	(l)	NA	NA	(l)	NA	1.27E-03	2.17E-03	3.45E-03	5.70E-04	1.95E-04	7.65E-04
Aerial	Forested	Helicopter	Typical	Long	NA	(l)	NA	NA	(l)	NA	7.53E-05	2.17E-03	2.25E-03	3.36E-05	1.95E-04	2.28E-04
Ground	Not applicable (j)	Low Boom (k)	Typical	Long	1.36E-03	(l)	1.36E-03	3.68E-03	(l)	3.68E-03	1.77E-04	2.17E-03	2.35E-03	3.20E-05	1.95E-04	2.27E-04
Ground	Not applicable (j)	High Boom (k)	Typical	Long	2.19E-03	(l)	2.19E-03	5.91E-03	(l)	5.91E-03	2.85E-04	2.17E-03	2.46E-03	5.13E-05	1.95E-04	2.46E-04
Aerial	Non-Forested	Plane	Maximum	Long	1.19E-02	(l)	1.19E-02	3.15E-02	(l)	3.15E-02	1.18E-03	4.18E-03	5.36E-03	3.38E-04	2.59E-04	5.97E-04
Aerial	Non-Forested	Helicopter	Maximum	Long	9.84E-03	(l)	9.84E-03	2.59E-02	(l)	2.59E-02	9.72E-04	4.18E-03	5.15E-03	2.75E-04	2.59E-04	5.34E-04
Aerial	Forested	Plane	Maximum	Long	NA	(l)	NA	NA	(l)	NA	2.57E-03	4.18E-03	6.75E-03	7.22E-04	2.59E-04	9.81E-04
Aerial	Forested	Helicopter	Maximum	Long	NA	(l)	NA	NA	(l)	NA	1.52E-04	4.18E-03	4.33E-03	4.30E-05	2.59E-04	3.02E-04
Ground	Not applicable (j)	Low Boom (k)	Maximum	Long	2.73E-03	(l)	2.73E-03	7.36E-03	(l)	7.36E-03	3.41E-04	4.18E-03	4.52E-03	4.26E-05	2.59E-04	3.02E-04
Ground	Not applicable (j)	High Boom (k)	Maximum	Long	4.38E-03	(l)	4.38E-03	6.84E-05	(l)	6.84E-05	5.47E-04	4.18E-03	4.73E-03	6.84E-05	2.59E-04	3.28E-04

Table 4-12
Final Pond Exposure Point Concentrations (Spray Drift and Runoff)

AgDRIFT® Scenario	Land Type (a)	Equipment	Application Rate Scenario (b)	Exposure Duration (c)	Aminopyralid (d) (mg a.e./L)	Clopyralid (d) (mg a.e./L)	2,4-D (e)				Fluroxypyr (d) (mg a.e./L)	Rimsulfuron (d,h) (mg a.i./L)
							Land (Annual/Perennial) (d) (mg a.e./L)	Land (Woody Species) (d) (mg a.e./L)	Aquatic (Floating/Emerged) (f) (mg a.e./L)	Aquatic (Submerged) (f,g) (mg a.e./L)		
Aerial	Non-Forested	Plane	Typical	Short	6.56E-02	2.69E-02	7.27E-02	1.40E-01	5.60E-03	1.62E-02	2.76E-02	3.55E-03
Aerial	Non-Forested	Helicopter	Typical	Short	6.55E-02	2.68E-02	7.23E-02	1.39E-01	4.56E-03	1.34E-02	3.04E-02	3.51E-03
Aerial	Forested	Plane	Typical	Short	6.61E-02	2.76E-02	7.52E-02	1.45E-01	NA	NA	2.84E-02	3.87E-03
Aerial	Forested	Helicopter	Typical	Short	6.52E-02	2.65E-02	7.05E-02	1.35E-01	NA	NA	2.72E-02	3.34E-03
Ground	Not applicable (i)	Low Boom (j)	Typical	Short	6.52E-02	2.66E-02	7.08E-02	1.36E-01	1.36E-03	3.68E-03	2.73E-02	3.34E-03
Ground	Not applicable (i)	High Boom (j)	Typical	Short	6.52E-02	2.67E-02	7.13E-02	1.37E-01	2.19E-03	5.91E-03	2.74E-02	3.35E-03
Aerial	Non-Forested	Plane	Maximum	Short	9.25E-02	5.40E-02	1.46E-01	2.81E-01	1.19E-02	3.15E-02	5.33E-02	4.74E-03
Aerial	Non-Forested	Helicopter	Maximum	Short	9.24E-02	5.38E-02	1.45E-01	2.79E-01	9.84E-03	2.59E-02	5.31E-02	4.68E-03
Aerial	Forested	Plane	Maximum	Short	9.33E-02	5.53E-02	1.50E-01	2.90E-01	NA	NA	5.47E-02	5.12E-03
Aerial	Forested	Helicopter	Maximum	Short	9.20E-02	5.30E-02	1.41E-01	2.70E-01	NA	NA	5.23E-02	4.44E-03
Ground	Not applicable (i)	Low Boom (j)	Maximum	Short	9.19E-02	5.31E-02	1.42E-01	2.72E-01	2.73E-03	7.36E-03	5.24E-02	4.44E-03
Ground	Not applicable (i)	High Boom (j)	Maximum	Short	9.20E-02	5.33E-02	1.61E-01	2.74E-01	4.38E-03	1.18E-02	5.26E-02	4.47E-03
Aerial	Non-Forested	Plane	Typical	Intermediate	6.39E-02	2.59E-02	4.97E-02	9.17E-02	5.60E-03	1.62E-02	1.86E-02	1.95E-03
Aerial	Non-Forested	Helicopter	Typical	Intermediate	6.39E-02	2.58E-02	4.92E-02	9.07E-02	4.56E-03	1.34E-02	2.13E-02	1.91E-03
Aerial	Forested	Plane	Typical	Intermediate	6.45E-02	2.66E-02	5.21E-02	9.62E-02	NA	NA	1.93E-02	2.28E-03
Aerial	Forested	Helicopter	Typical	Intermediate	6.35E-02	2.54E-02	4.74E-02	8.67E-02	NA	NA	1.81E-02	1.74E-03
Ground	Not applicable (i)	Low Boom (j)	Typical	Intermediate	6.35E-02	2.55E-02	4.78E-02	8.75E-02	1.36E-03	3.68E-03	1.82E-02	1.74E-03
Ground	Not applicable (i)	High Boom (j)	Typical	Intermediate	6.36E-02	2.56E-02	4.82E-02	8.83E-02	2.19E-03	5.91E-03	1.83E-02	1.76E-03
Aerial	Non-Forested	Plane	Maximum	Intermediate	9.02E-02	5.19E-02	9.98E-02	1.84E-01	1.19E-02	3.15E-02	3.58E-02	2.61E-03
Aerial	Non-Forested	Helicopter	Maximum	Intermediate	9.01E-02	5.17E-02	9.88E-02	1.82E-01	9.84E-03	2.59E-02	3.56E-02	2.55E-03
Aerial	Forested	Plane	Maximum	Intermediate	9.09E-02	5.32E-02	1.04E-01	1.93E-01	NA	NA	3.72E-02	2.99E-03
Aerial	Forested	Helicopter	Maximum	Intermediate	8.96E-02	5.09E-02	9.48E-02	1.73E-01	NA	NA	3.48E-02	2.32E-03
Ground	Not applicable (i)	Low Boom (j)	Maximum	Intermediate	8.96E-02	5.11E-02	9.56E-02	1.75E-01	2.73E-03	7.36E-03	3.50E-02	2.32E-03
Ground	Not applicable (i)	High Boom (j)	Maximum	Intermediate	8.97E-02	5.13E-02	1.15E-01	1.77E-01	4.38E-03	1.18E-02	3.52E-02	2.34E-03
Aerial	Non-Forested	Plane	Typical	Long	4.54E-02	4.63E-03	7.67E-03	1.48E-02	5.60E-03	1.62E-02	2.72E-03	4.42E-04
Aerial	Non-Forested	Helicopter	Typical	Long	4.54E-02	4.55E-03	7.24E-03	1.38E-02	4.56E-03	1.34E-02	5.44E-03	3.98E-04
Aerial	Forested	Plane	Typical	Long	4.60E-02	5.34E-03	1.01E-02	1.93E-02	NA	NA	3.45E-03	7.65E-04
Aerial	Forested	Helicopter	Typical	Long	4.50E-02	4.18E-03	5.40E-03	9.80E-03	NA	NA	2.25E-03	2.28E-04
Ground	Not applicable (i)	Low Boom (j)	Typical	Long	4.50E-02	4.28E-03	5.79E-03	1.06E-02	1.36E-03	3.68E-03	2.35E-03	2.27E-04
Ground	Not applicable (i)	High Boom (j)	Typical	Long	4.51E-02	4.38E-03	6.20E-03	1.14E-02	2.19E-03	5.91E-03	2.46E-03	2.46E-04
Aerial	Non-Forested	Plane	Maximum	Long	6.41E-02	9.41E-03	1.58E-02	3.04E-02	1.19E-02	3.15E-02	5.36E-03	5.97E-04
Aerial	Non-Forested	Helicopter	Maximum	Long	6.40E-02	9.19E-03	1.48E-02	2.83E-02	9.84E-03	2.59E-02	5.15E-03	5.34E-04
Aerial	Forested	Plane	Maximum	Long	6.48E-02	1.07E-02	2.03E-02	3.92E-02	NA	NA	6.75E-03	9.81E-04
Aerial	Forested	Helicopter	Maximum	Long	6.35E-02	8.37E-03	1.08E-02	1.96E-02	NA	NA	4.33E-03	3.02E-04
Ground	Not applicable (i)	Low Boom (j)	Maximum	Long	6.35E-02	8.56E-03	1.16E-02	2.12E-02	2.73E-03	7.36E-03	4.52E-03	3.02E-04
Ground	Not applicable (i)	High Boom (j)	Maximum	Long	6.36E-02	8.76E-03	3.12E-02	2.29E-02	4.38E-03	6.84E-05	4.73E-03	3.28E-04

a.e. - acid equivalent.
a.i. - active ingredient.
NA - Not Applicable. Deposition on a pond is simulated using the non-forested land type option.
(a) - Land type selected in AgDRIFT® to calculate deposition rates for aerial scenarios using the Tier II version of the model.
(b) - See Table 4-1.
(c) - Runoff concentrations were modeled assuming short (7-day), intermediate (30 day), or long (annual) term exposure durations.
(d) - Terrestrial herbicide. Concentration is the sum of spray drift input (AgDRIFT®) and runoff (GLEAMS®). See Table 4-11 for calculation.
(e) - Deposition rates were derived for three of the four 2,4-D application scenarios; deposition rates were not derived for the scenario involving granular application via boat. See Table 4-1. For the aquatic applications, it is assumed that spray drift settles onto
(f) - Aquatic herbicide. Pond concentration is the spray drift input (AgDRIFT®; (Table 4-9).
(g) - Deposition rates for spray drift from this herbicide were calculated assuming a pond size of 1 acre and 1 foot, as the application rates for this formulation are in lb a.e./acre-foot.
(h) - Typical application rate scenario is applicable to rangeland and public-domain forest land. Maximum application rate scenario is applicable to all five land programs.
(i) - Land type not applicable to ground applications, which are evaluated using the Tier I version of the model.
(j) - Boom/broadcast applications (see Table 4-1) can be conducted using low or high booms, which are evaluated separately here as boom height affects the deposition rate of off-site drift.

Table 4-13
Calculation of Pond Exposure Point Concentrations - Direct Spray to Pond/Pond Re-entry - Maximum Application Rate Scenario

Herbicide	Maximum Application Rate	Application Rate Units	Pond Depth (feet)	Unit Correction Factor (acre/feet^2)	Unit Correction Factor (mg/lb)	Unit Correction Factor (ft^3/m^3)	Unit Correction Factor (m^3/L)	Pond EPC		EPC Units
Aminopyralid (a)	0.11	lb a.e./acre	3.28	43,560	453,600	35.31	0.001	0.01	(b)	mg a.e./L
Clopyralid (a)	0.5	lb a.e./acre	3.28	43,560	453,600	35.31	0.001	0.1	(b)	mg a.e./L
2,4-D (Land - Annual/Perennial) (a)	2	lb a.e./acre	3.28	43,560	453,600	35.31	0.001	0.2	(b)	mg a.e./L
2,4-D (Land - Woody Species) (a)	4	lb a.e./acre	3.28	43,560	453,600	35.31	0.001	0.4	(b)	mg a.e./L
2,4-D (Aquatic - Floating and Emerged) (c)	4	lb a.e./acre	3.28	43,560	453,600	35.31	0.001	0.4	(b)	mg a.e./L
2,4-D (Aquatic - Submerged; liquid) (c)	10.8	lb a.e./acre-foot	NA	43,560	453,600	35.31	0.001	4	(d)	mg a.e./L
2,4-D (Aquatic - Submerged; granular) (e)	38	lb a.e./acre	3.28	43,560	453,600	35.31	0.001	4	(b)	mg a.e./L
Fluroxypyr (a)	0.5	lb a.e./acre	3.28	43,560	453,600	35.31	0.001	0.1	(b)	mg a.e./L
Rimsulfuron (a)	0.0625	lb a.i./acre	3.28	43,560	453,600	35.31	0.001	0.01	(b)	mg a.i./L

a.e. - acid equivalent.
a.i. - active ingredient.
EPC - Exposure Point Concentration.
NA - Not Applicable; calculation is independent of pond depth as application rate is in lb a.e./acre-foot.
(a) - Assumes that a non-target pond is accidentally sprayed.
(b) - EPC (mg [a.i. or a.e.]/L) = application rate (lb [a.e. or a.i.]/acre) x 1/pond depth (ft) x acre/43,560 ft2 x 453,600 mg/lb x 35.31 ft3/m3 x 0.001 m3/L.
(c) - Because this herbicide may be applied aerially and is for aquatic scenarios, both the accidental spray of a non-target pond and the re-entry scenario could be applicable.
(d) - EPC (mg a.e.]/L) = application rate (lb a.e./acre-foot) x acre/43,560 ft2 x 453,600 mg/lb x 35.31 ft3/m3 x 0.001 m3/L.
(e) - Boat applications only. Assumes that pond is treated with granular product and receptor enters pond even though warning signs are posted.

Table 4-14
Calculation of Pond Concentrations - Direct Spray to Pond/Pond Re-entry - Typical Application Rate Scenario

Herbicide (a)	Typical Application Rate	Application Rate Units	Pond Depth (feet)	Unit Correction Factor (acre/feet^2)	Unit Correction Factor (mg/lb)	Unit Correction Factor (ft^3/m^3)	Unit Correction Factor (m^3/L)	Pond EPC		EPC Units
2,4-D (Land - Annual/Perennial) (b)	1	lb a.e./acre	3.28	43,560	453,600	35.31	0.001	0.1	(c)	mg a.e./L
2,4-D (Land - Woody Species) (b)	2	lb a.e./acre	3.28	43,560	453,600	35.31	0.001	0.2	(c)	mg a.e./L
2,4-D (Aquatic - Floating and Emerged) (d)	2	lb a.e./acre	3.28	43,560	453,600	35.31	0.001	0.2	(c)	mg a.e./L
2,4-D (Aquatic - Submerged; liquid) (d)	5.4	lb a.e./acre-foot	NA	43,560	453,600	35.31	0.001	2	(e)	mg a.e./L
2,4-D (Aquatic - Submerged; granular) (f)	19	lb a.e./acre	3.28	43,560	453,600	35.31	0.001	2	(c)	mg a.e./L

a.e. - acid equivalent.
a.i. - active ingredient.
EPC - Exposure Point Concentration.
NA - Not Applicable; calculation is independent of pond depth as application rate is in lb a.e./acre-foot.
(a) - The typical application rate scenario was evaluated for 2,4-D. See text.
(b) - Assumes that a non-target pond is accidentally sprayed.
(c) - Concentration (mg [a.i. or a.e.]/L) = application rate (lb [a.e. or a.i.]/acre) x 1/pond depth (ft) x acre/43,560 ft2 x 453,600 mg/lb x 35.31 ft3/m3 x 0.001 m3/L.
(d) - Because this herbicide may be applied aerially and is for aquatic scenarios, both the accidental spray of a non-target pond and the re-entry scenario could be applicable.
(e) - EPC (mg a.e.]/L) = application rate (lb a.e./acre-foot) x acre/43,560 ft2 x 453,600 mg/lb x 35.31 ft3/m3 x 0.001 m3/L
(f) - Boat applications only. Assumes that pond is treated with granular product and receptor enters pond even though warning signs are posted.

Table 4-15
Calculation of Pond Exposure Point Concentrations - Spill to Pond - Maximum Application Rate Scenario

Herbicide	Spill Source	Amount Spilled (a) (gallons)	Maximum Application Rate (b)	Application Rate Units	Lowest Spray Rate (c) (gal/acre)	Spray Rate Units	Concentration in Mix (d)	Mix Concentration Units	Unit Correction Factor (mg/lb)	Unit Correction Factor (ft^3/m^3)	Unit Correction Factor (m^3/L)	Pond Size (acre)	Pond Depth (feet)	Unit Correction Factor ($ft^2/acre$)	Pond EPC (e)	EPC Units
Aminopyralid	Helicopter	140	0.11	lb a.e./acre	5	gal/acre	0.022	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	1.38	mg a.e./L
Clopyralid	Helicopter	140	0.5	lb a.e./acre	5	gal/acre	0.1	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	6.28	mg a.e./L
2,4-D (Land - Annual/Perennial)	Helicopter	140	2	lb a.e./acre	5	gal/acre	0.4	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	25.11	mg a.e./L
2,4-D (Land - Woody Species)	Helicopter	140	4	lb a.e./acre	5	gal/acre	0.8	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	50.22	mg a.e./L
2,4-D (Aquatic - Floating and Emerged)	Helicopter	140	4	lb a.e./acre	5	gal/acre	0.8	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	50.22	mg a.e./L
2,4-D (Aquatic - Submerged; liquid)	Helicopter	140	10.8	lb a.e./acre-foot	5	gal/acre-foot	2.2	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	135.60	mg a.e./L
2,4-D (Aquatic - Submerged; granular)	NA	NA	NA	NA	NA	gal/acre	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluroxypyr	Helicopter	140	0.5	lb a.e./acre	5	gal/acre	0.1	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	6.28	mg a.e./L
Rimsulfuron	Helicopter	140	0.0625	lb a.i./acre	5	gal/acre	0.0125	lb a.i./gallon	453,600	35.31	0.001	0.25	3.28	43,560	0.78	mg a.i./L
Aminopyralid	Truck	200	0.11	lb a.e./acre	25	gal/acre	0.0044	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	0.39	mg a.e./L
Clopyralid	Truck	200	0.5	lb a.e./acre	25	gal/acre	0.02	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	1.79	mg a.e./L
2,4-D (Land - Annual/Perennial)	Truck	200	2	lb a.e./acre	25	gal/acre	0.08	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	7.17	mg a.e./L
2,4-D (Land - Woody Species)	Truck	200	4	lb a.e./acre	25	gal/acre	0.16	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	14.35	mg a.e./L
2,4-D (Aquatic - Floating and Emerged)	Truck	200	4	lb a.e./acre	25	gal/acre	0.16	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	14.35	mg a.e./L
2,4-D (Aquatic - Submerged; liquid)	Truck	200	10.8	lb a.e./acre-foot	25	gal/acre-foot	0.4	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	38.74	mg a.e./L
2,4-D (Aquatic - Submerged; granular)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluroxypyr	Truck	200	0.5	lb a.e./acre	25	gal/acre	0.02	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	1.79	mg a.e./L
Rimsulfuron	Truck	200	0.0625	lb a.i./acre	25	gal/acre	0.0025	lb a.i./gallon	453,600	35.31	0.001	0.25	3.28	43,560	0.22	mg a.i./L

a.e. - acid equivalent.
a.i. - active ingredient.
EPC - Exposure Point Concentration.
NA - Not Applicable. Product is granular and is applied via boat only. An accidental spill from a boat is not considered relevant as it is assumed that all product on-board is intended for pond treatment.
(a) - These amounts are approximately the largest amounts that can be carried in helicopters (140 gallons) or trucks (200 gallons) as used by BLM.
(b) - See Table 4-1. The granular form of 2,4-D is not applied via helicopter or truck, and a spill from a boat is not applicable as the boat is assumed to carry on board the amount of product for pond treatment. Therefore, spill concentrations are not calculated. However, a pond concentration assuming direct treatment of the pond was calculated in Table 4-13 for use in a scenario where a receptor enters pond even though warning signs are posted.
(c) - These amounts are approximately the lowest spray rates of a helicopter (5 gallons/acre) and a truck (25 gallons/acre) as used by BLM.
(d) - Concentration in mix (lb a.e. or a.i./gallon) = Maximum Application Rate (lb a.e. or a.i./acre) / Lowest Spray Rate (gal/acre), except 2,4-D (Aquatic - Submerged; liquid), where the concentration in mix = Maximum Application Rate (lb a.e./acre-foot) / Lowest Spray Rate (gal/acre-foot).
(e) - EPC (mg a.e. or a.i./L) = Spill amount (gallons) x concentration in mix (lb a.e. or a.i./gallon) x 453,600 mg/lb x 35.31 ft3/m3 x 0.001 m3/L / 43,560 ft2/acre x pond size (acres) x pond depth (feet).

Table 4-16
Calculation of Pond Concentrations - Spill to Pond - Typical Application Rate Scenario

Herbicide	Spill Source	Amount Spilled (a) (gallons)	Typical Application Rate (b)	Application Rate Units	Lowest Spray Rate (c) (gal/acre)	Spray Rate Units	Concentration in Mix (d)	Mix Concentration Units	Unit Correction Factor (mg/lb)	Unit Correction Factor (ft^3/m^3)	Unit Correction Factor (m^3/L)	Pond Size (acre)	Pond Depth (feet)	Unit Correction Factor ($ft^2/acre$)	Pond EPC (e)	EPC Units
2,4-D (Land - Annual/Perennial)	Helicopter	140	1	lb a.e./acre	5	gal/acre	0.2	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	12.56	mg a.e./L
2,4-D (Land - Woody Species)	Helicopter	140	2	lb a.e./acre	5	gal/acre	0.4	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	25.11	mg a.e./L
2,4-D (Aquatic - Floating and Emerged)	Helicopter	140	2	lb a.e./acre	5	gal/acre	0.4	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	25.11	mg a.e./L
2,4-D (Aquatic - Submerged; liquid)	Helicopter	140	5.4	lb a.e./acre-foot	5	gal/acre-foot	1.1	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	67.80	mg a.e./L
2,4-D (Aquatic - Submerged; granular)	NA	NA	NA	NA	NA	gal/acre	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-D (Land - Annual/Perennial)	Truck	200	1	lb a.e./acre	25	gal/acre	0.04	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	3.59	mg a.e./L
2,4-D (Land - Woody Species)	Truck	200	2	lb a.e./acre	25	gal/acre	0.08	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	7.17	mg a.e./L
2,4-D (Aquatic - Floating and Emerged)	Truck	200	2	lb a.e./acre	25	gal/acre	0.08	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	7.17	mg a.e./L
2,4-D (Aquatic - Submerged; liquid)	Truck	200	5.4	lb a.e./acre-foot	25	gal/acre-foot	0.2	lb a.e./gallon	453,600	35.31	0.001	0.25	3.28	43,560	19.37	mg a.e./L
2,4-D (Aquatic - Submerged; granular)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

a.e. - acid equivalent.
a.i. - active ingredient.
EPC - Exposure Point Concentration.
NA - Not Applicable. Product is granular and is applied via boat only. An accidental spill from a boat is not considered relevant as it is assumed that all product on-board is intended for pond treatment.
(a) - These amounts are approximately the largest amounts that can be carried in helicopters (140 gallons) or trucks (200 gallons) as used by BLM.
(b) - See Table 4-1. The granular form of 2,4-D is not applied via helicopter or truck, and a spill from a boat is not applicable as the boat is assumed to carry on board the amount of product for pond treatment.
Therefore, spill concentrations are not calculated. However, a pond concentration assuming direct treatment of the pond was calculated in Table 4-14 for use in a scenario where a receptor enters pond even though warning signs are posted.
(c) - These amounts are approximately the lowest spray rates of a helicopter (5 gallons/acre) and a truck (25 gallons/acre) as used by BLM.
(d) - Concentration in mix (lb a.e. or a.i./gallon) = Maximum Application Rate (lb a.e. or a.i./acre) / Lowest Spray Rate (gal/acre) except 2,4-D (Aquatic - Submerged; liquid), where the concentration in mix =
Maximum Application Rate (lb a.e./acre-foot) / Lowest Spray Rate (gal/acre-foot).
(e) - EPC (mg a.e. or a.i./L) = Spill amount (gallons) x concentration in mix (lb a.e. or a.i./gallon) x 453,600 mg/lb x 35.31 ft3/m3 x 0.001 m3/L / 43,560 ft2/acre x pond size (acres) x pond depth (feet).

Table 4-17
Summary of Absorption Factors

Herbicide Active Ingredient	Dermal Absorption Factor		Inhalation Absorption Factor	Reference
Aminopyralid	NA	(a)	1	USEPA 2009a
Clopyralid	NA	(a)	1	USEPA 2009b
2,4-D	0.1		1	USEPA 2005a,b
Fluroxypyr	NA	(a)	1	USEPA 2007a
Rimsulfuron	0.17	(b)	1	USEPA 2011c

NA - Not Applicable.
(a) - No systemic toxicity seen at the limit dose (1,000 mg/kg-day). Therefore, USEPA determined that dermal risk assessment is not necessary.
(b) - J. Evans, USEPA Office of Pesticide Programs (OPP) personal communication, 4/3/2012.

References:

USEPA 2005a. Reregistration Eligibility Decision for 2,4-D. EPA 738-R-05-002. June 2005. Available at: www.epa.gov/oppsrrd1/REDs/24d_red.pdf.

USEPA 2005b. 2,4-D. HED's Revised Human Health Risk Assessment for the Reregistration Eligibility Decision (RED) Revised to Reflect Public Comments. May 12, 2005. Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2004-0167-0219.

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USEPA 2009a. Aminopyralid. Human Health Risk Assessment for the Proposed Use on Field Corn (PP#8F7455). October 22, 2009. Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0141-0006.

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Table 4-18
Summary of Skin Permeability Constants

Herbicide Active Ingredient	Chemical Specific Data (a) Molecular Weight (g/mole)	Reference	Log Kow	Reference	Calculations Log Kp (b)	Kp (cm/hr)
Aminopyralid	207.02	USEPA 2005d	-2.87	USEPA 2009a (pH 7)	-5.853512	1.40E-06
Clopyralid	192	Budavari 1989	-2.63	USEPA 2009b (20^{o}C)	-5.611	2.45E-06
2,4-D	221	USEPA 2005a	-0.75	USDA 2009 (pH 7)	-4.5326	2.93E-05
Fluroxypyr	367.2	Tomlin 2004	5.04	Tomlin 2009 (pH 7)	-1.52992	2.95E-02
Rimsulfuron	431.44	CalEPA 1997	0.0345	CalEPA 1997 (pH 7)	-5.193294	6.41E-06

Kow - Octanol-Water Partition Coefficient.
Kp - Skin Permeability Constant.
(a) - Values are for the acid form, with the exception of fluroxypyr. Values for the methylhepanol ester (MHE) form of fluroxypyr are used to calculate the PC because this form is expected to absorb through the skin faster than the acid form.
(b) - USEPA 2004. Supplemental Guidance for Dermal Risk Assessment, Equation 3.8: Log Kp = -2.80 + 0.66 log Kow - 0.0056 MW.

References:

Budavari 1989. The Merck Index: An Encyclopedia of Chemicals, Drugs, and Biologicals, 11th ed. Merck & Co., Inc., Rahway, New Jersey.
CalEPA 1997. Assessment of the Tolerances for Section 3 Registration of ShadeoutTM (Rimsulfuron) on Tomatoes. Department of Pesticide Regulation. October 21, 1997.
Tomlin 2009. Tomlin, C. 2009. The Pesticide Manual, Fifteenth Edition, Crop Protection Publications; British Crop Protection Council.
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USEPA 2005a. Reregistration Eligibility Decision for 2,4-D. EPA 738-R-05-002. June 2005. Available at: www.epa.gov/oppsrrd1/REDs/24d_red.pdf.
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USEPA 2009a. Aminopyralid. Human Health Risk Assessment for the Proposed Use on Field Corn (PP#8F7455). October 22, 2009. Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0141-0006.
USEPA 2009b. Clopyralid. Human Health Risk Assessment to Evaluate New Uses on Swiss Chard, Bushberry Subgroup (13-07B) and Strawberry (Regional Restriction). December 3, 2009. Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0092-0005.

Table 4-19
Summary of Bioconcentration Factors

Herbicide	Bioconcentration Factor (L/kg)	Reference
Aminopyralid	1	USEPA 2005d
Clopyralid	1	Bidlack 1982; MRID 00128464
2,4-D	1	Data presented in USEPA 2005b suggests no bioconcentration.
Fluroxypyr	6.06	Rick et al. 1996; MRID 44080348, value for edible tissue, rainbow trout, MHE form.
Rimsulfuron	1	CalEPA 1997

References:
Bidlack, H. 1982. Determination of the Bioconcentration Factor for 3,6-Dichloropicolinic Acid in Bluegill Sunfish during continuous Aqueous Exposure: GH-C 1577. MRID No. 00128464.
CalEPA 1997. Assessment of the Tolerances for Section 3 Registration of ShadeoutTM (Rimsulfuron) on Tomatoes. Department of Pesticide Regulation. October 21, 1997.
Rick, D.L., A.M. Landre, and H.D. Kirk. 1996. The Bioconcentration and Metabolism of Fluroxypyr 1-Methylheptyl Ester by the Rainbow Trout (Oncorhynchus mykiss Walbaum). Study ID DECO-ES-2679. Unpublished Study Prepared by the Environmental Toxicology Research Laboratory, Health and Environmental Science, Dow Chemical Company, Midland, Michigan. 57 p. MRID Number 44080348.
USEPA 2005d. Environmental Fate and Ecological Risk Assessment for the Registration of Aminopyralid.
USEPA 2005b. 2,4-D. HED's Revised Human Health Risk Assessment for the Reregistration Eligibility Decision (RED) Revised to Reflect Public Comments. May 12, 2005. Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2004-0167-0219.

5.0 RISK CHARACTERIZATION

The purpose of the risk characterization is to provide estimates of the potential risk to human health from exposure to herbicide a.i.s. The results of the exposure assessment are combined with the results of the dose-response assessment to derive quantitative estimates of risk, or the probability of adverse health effects following assumed potential exposure to herbicide a.i.s. Since none of the herbicide a.i.s evaluated in this HHRA are considered to be potential carcinogens by the USEPA, the potential noncancer risk associated with the herbicide use scenarios is estimated.

The USEPA risk assessment guidance for pesticides provides different noncancer methods for evaluating food and non-dietary exposures (USEPA 2000). For dietary exposure, the %PAD method is used, and for non-dietary exposure, an MOE method is used. In order to estimate total exposure and risk from all exposure pathways, the USEPA has also developed an aggregate risk approach, which combines potential risks from various pathways expressed as MOEs and %PADs (USEPA 1999a, 2001).

Section 5.1 discusses the overall approach for risk characterization, Section 5.2 presents equations for quantifying exposure and risk, Section 5.3 presents the results of the risk characterization, and Section 5.4 discusses uncertainties inherent in the risk assessment process.

5.1 Approach for Risk Characterization

The dietary (%PAD) and non-dietary (MOE) methods are summarized below, followed by the aggregate risk approach for combining these risk estimates.

5.1.1 Dietary (%PAD) Assessment

This assessment method evaluates exposures to active ingredient residues in food and water. Toxicity is represented by a PAD and may be calculated for acute effects (acute PAD) or chronic effects (chronic PAD). A PAD is defined as an acute or chronic RfD divided by the FQPA SF (a value between 1 and 10), where appropriate (discussed in Section 3.0).

The noncancer risk estimate is the ratio of the exposure level (expressed as intake of the herbicide active ingredient in mg/kg-day) to the PAD, and is calculated using the following equation:

$$\%PAD = \frac{Food\ Intake\ (mg/kg-day)}{PAD(mg/kg-day)} * 100\%$$

Exposures that are less than 100% of the PAD do not exceed the USEPA’s level of concern, indicating that adverse health effects are not expected.

As shown in Table 3-1, clopyralid and 2,4-D have acute PADs developed by the USEPA. Chronic PADs are available for aminopyralid, clopyralid, 2,4-D, fluroxypyr, and rimsulfuron. The FQPA SF for each of these herbicide active ingredients is 1; therefore, the PAD is equal to the RfD.

5.1.2 Non-dietary (MOE) Assessment

This assessment method evaluates exposures via all non-dietary pathways (e.g., ingestion, dermal, inhalation). The toxicity of the chemical is represented by a NOAEL identified from the scientific literature. The noncancer risk estimate is the ratio of the toxicity value to the exposure level, and is calculated using the following general equation:

$$\text{Noncancer, MOE} = \frac{\text{NOAEL(mg/kg – day)}}{\text{Exposure(mg/kg – day)}}$$

Target MOEs are derived to account for the uncertainties associated with the NOAEL. Target MOEs are generally set at 100 to account for a factor of 10 for interspecies extrapolation and factor of 10 for intraspecies variability. Additional factors are applied when a LOAEL is used rather than a NOAEL. Calculated MOEs above the target MOE do not exceed the USEPA's level of concern. Calculated MOE values less than the target MOE indicate a potential concern for human health, while calculated MOE values above the target MOE indicate that adverse health effects are not expected. As shown in Table 3-1, target MOEs are defined for each of the herbicide active ingredients for which oral, dermal, and inhalation NOAELs have not been developed due to a lack of toxic effect. Target MOEs are 100 for all herbicide active ingredients, except for residential exposure to 2,4-D. The 2,4-D target MOE for residential exposures is 1,000; the additional factor of 10 was included to account for database insufficiencies.

5.1.3 Aggregate Risk Index

The %PAD method presents the risk result as the exposure estimate divided by the allowable exposure level (the PAD), and is expressed as a percentage of the total allowable exposure. Results less than or equal to 100% of the PAD are considered acceptable. However, for the MOE method, the identified NOAEL is divided by the estimated exposure, and is, therefore, the reverse of the %PAD method. For the MOE method, when the ratio is greater than the target MOE, the risk is considered to be negligible. Risk results obtained using these different methods cannot be directly combined to account for cumulative risk from various exposure pathways. An aggregate approach, described below, is therefore used.

The USEPA's OPP (USEPA 1999a, 2001) has developed the Aggregate Risk Index (ARI) approach, which combines potential risks from various pathways expressed as MOEs and %PADs. In this approach, it is important that only exposure pathways encompassing similar exposure durations be combined (i.e., acute exposures cannot be combined with chronic exposures). The ARI is an extension of the MOE concept. The ARI is compared against a target value of 1. Values greater than 1 do not exceed the USEPA's level of concern and indicate that no adverse health effects are expected; values below 1 indicate a potential concern for human health.

The ARI method allows for direct comparisons between routes and between chemicals. The ARI method considers each route's potency when route-specific NOAELs that may have different target MOEs are used. Note that the USEPA (1999a) designates target MOEs as uncertainty factors. This report uses the term target MOEs, for consistency with Section 3.0, Dose-Response Assessment. The %PAD calculated for dietary exposures can also be incorporated into the ARI approach, using the following equation:

$$\text{ARI} = \frac{1}{\%\text{PAD}_O + \frac{\text{TM}_D}{\text{MOE}_D} + \frac{\text{TM}_I}{\text{MOE}_I}}$$

where:

ARI	=	Aggregate Risk Index
$\%PAD_O$	=	%PAD for oral exposure, expressed as a ratio (i.e., 80% = 0.8)
TM_D	=	Target MOE for dermal exposure
MOE_D	=	Site-specific MOE estimated for dermal exposure
TM_I	=	Target MOE for inhalation exposure
MOE_I	=	Site-specific MOE estimated for inhalation exposure

Not all herbicide active ingredients include all of these toxicity endpoints. For example, some herbicide active ingredients may not be toxic through the dermal route; therefore, the dermal MOE would not be included. The USEPA (1999a) provides the following example for an herbicide active ingredient and receptor that has a dermal MOE of 100, a dermal target MOE of 100, an inhalation MOE of 1,000, an inhalation target MOE of 300, and an oral %PAD of 80% (expressed as a ratio, 0.8):

$$ARI = \frac{1}{0.8_o + \frac{100_D}{100_D} + \frac{300_I}{1000_I}} = 0.48$$

In this example, the ARI (0.48) suggests a level of concern because it is less than 1. It should be noted that, when listed separately, the oral PAD would be listed as % oral PAD (in this case, 80%). However, when included in this equation, the actual fraction (not the percentage) is used.

Therefore, for this HHRA, the %PAD approach has been used to evaluate potential exposures to herbicide active ingredients in food and water, the MOE approach has been used to evaluate potential exposures to herbicide active ingredients via non-dietary and incidental ingestion pathways, and the ARI approach has been used to evaluate combined exposures.

5.2 Equations for Quantifying Potential Exposure and Risk

To estimate the potential risk to receptors from exposure to herbicide a.i.s, it is first necessary to estimate the potential exposure dose of each herbicide a.i. The exposure dose is estimated for each herbicide a.i. via each exposure pathway by which the receptor is assumed to be exposed. Exposure dose equations combine the estimates of herbicide a.i. concentration in the environmental medium of interest with assumptions about the type and magnitude of each receptor's potential exposure, to provide a numerical estimate of the exposure dose. The exposure dose is defined as the amount of herbicide a.i. taken into the receptor, and is expressed in units of mg of herbicide a.i/kg of body weight per day (mg/kg-day). Exposure doses are calculated separately for different time frames, such as short-term, intermediate-term, and long-term exposures.

The standardized equations for estimating a receptor's average daily dose are presented below. The following sections also show whether the dose is used with a NOAEL or PAD to estimate risks. NOAELs are used for non-dietary and incidental ingestion (such as ingestion of water while swimming) pathways to calculate MOEs. Potential risks from dietary exposure (such as drinking water, berry ingestion, and fish ingestion) are estimated using PADs. Table 5-1 indicates which NOAELs and/or PADs are used in the derivation of ARIs for each scenario.

5.2.1 Estimating Potential Occupational Exposures

Occupational exposures via dermal contact and inhalation are evaluated using the unit exposure values (as presented in Table 4-2). For the worker accidental exposure, it is assumed that the worker receives a direct spill and is exposed through dermal contact. The equations used are as follows (additional information is provided for parameters in the equations that have not already been defined).

5.2.1.1 Dermal Contact with Herbicide Active Ingredient

The following equation is used to evaluate occupational exposure through dermal contact:

$$Dose_{routine}(mg/kg-day) = \frac{AR\ (lb\ a.e.\ or\ a.i./acre) * AT\ (acres/hour) * H\ (hours/day) * UE_{derm}(mg\ a.i./lb\ a.i.) * DAF(unitless)}{BW\ (kg)}$$

$$Dose_{accident}\ (mg/kg-day) = \frac{S\ (L/day) * Cs\ (mg\ a.e.\ or\ a.i./L) * SAR(unitless) * DAF(unitless)}{BW\ (kg)}$$

where:

Parameter	Units	Definition
AR	lb a.e. or a.i./acre	Herbicide Active Ingredient Application Rate (Table 4-1)
AT	acres/hour	Acres Treated per hour (Table 4-2)
H	hours/day	Hours treated per day (Table 4-2)
UE_{derm}	mg a.i./lb a.i.	Dermal Unit Exposure Factor (Table 4-2)
DAF	unitless	Dermal Absorption Factor (Table 4-17)
S	L/day	Spill amount = 0.5 L of concentrate
SAR	unitless	Surface Area Ratio - Ratio of surface area exposed to total surface area, expressed as a percent (80% spilled to clothing, with a 30% penetration rate, and 20% spilled to bare skin. [(0.8*0.3)+0.2 = 0.44]).
BW	kg	Body Weight (Table 4-2)
Cs	mg a.e. or a.i./L	Concentration of active ingredient in concentrate (Table 4-6). Obtained from label and converted as follows for aminopyralid, clopyralid, 2,4-D (not applicable to the granular formulation, which is not mixed with water prior to application), and fluroxypyr: Cs = lb [a.e. or a.i.]/gallon * 453,600 mg/lb * 1 gallon/3.78 L Rimsulfuron is present in a granular or dry flowable formulation. Cs was calculated as follows: Cs = Maximum AR (0.0625 lb a.i./acre) / Lowest Spray Rate (5 gallons/acre) = 0.0125 lbs a.i./acre.

The application rate for the formulation of 2,4-D used to treat a volume of water is in units of lb a.e./acre-foot. In order to use the application rate in the equation above, a pond depth of 1 foot was assumed.

MOEs are calculated as follows:

Dose	NOAEL Type	MOE Equation
Routine - Dermal	Dermal - Short-term (ds)	$\frac{NOAEL_{ds}\ (mg/kg-day)}{Dose_{routine}\ (mg/kg-day)}$
	Dermal - Intermediate-term (di)	$\frac{NOAEL_{di}\ (mg/kg-day)}{Dose_{routine}\ (mg/kg-day)}$
	Dermal - Long-term (dl)	$\frac{NOAEL_{dl}\ (mg/kg-day)}{Dose_{routine}\ (mg/kg-day)}$
Accident	Dermal - Short-term (ds)	$\frac{NOAEL_{ds}\ (mg/kg-day)}{Dose_{accident}\ (mg/kg-day)}$

Table 3-1 lists the short-term, intermediate-term and long-term dermal NOAELs for the five herbicide active ingredients. Dermal NOAELs are available for 2,4-D. There are no dermal NOAELs for aminopyralid, clopyralid, fluroxypyr, or rimsulfuron because they have not been shown to result in toxicity after dermal exposure. Therefore, potential dermal risks were not calculated for these herbicide active ingredients and specific time frames that lack dermal NOAELs.

5.2.1.2 Inhalation of Herbicide Active Ingredient

The following equation is used to evaluate occupational exposure through inhalation:

$$\text{Dose}_{\text{routine}} (\text{mg / kg} - \text{day}) =$$

$$\frac{\text{AR (lb a.e. or a.i. / acre)} * \text{AT (acres / hour)} * \text{H (hours / day)} * \text{UE}_{\text{inh}} \text{ (mg a.i. / lb a.i.)} * \text{IAF(unitless)}}{\text{BW (kg)}}$$

where:

Parameter	Units	Definition
AR	lb a.i./acre	Herbicide Active Ingredient Application Rate (Table 4-1)
AT	acres/hour	Acres Treated per hour (Table 4-2)
H	hours/day	Hours treated per day (Table 4-2)
UE_{inh}	mg a.i./lb a.i.	Inhalation Unit Exposure (Table 4-2)
BW	kg	Body Weight (Table 4-2)
IAF	unitless	Inhalation Absorption Factor (Table 4-17)

The application rate for the formulation of 2,4-D used to treat a volume of water is in units of lb a.e./acre-foot. In order to use the application rate in the equation above, a pond depth of 1 foot was assumed.

MOEs are calculated as follows:

Dose	NOAEL Type	MOE Equation
Routine	Inhalation - Short-term (is)	$\frac{\text{NOAEL}_{\text{is}} \text{ (mg / kg} - \text{day)}}{\text{Dose}_{\text{routine}} \text{ (mg / kg} - \text{day)}}$
	Inhalation - Intermediate-term (ii)	$\frac{\text{NOAEL}_{\text{ii}} \text{ (mg / kg} - \text{day)}}{\text{Dose}_{\text{routine}} \text{ (mg / kg} - \text{day)}}$
	Inhalation - Long-term (il)	$\frac{\text{NOAEL}_{\text{il}} \text{ (mg / kg} - \text{day)}}{\text{Dose}_{\text{routine}} \text{ (mg / kg} - \text{day)}}$

Table 3-1 lists the short-term, intermediate-term, and long-term inhalation NOAELs for the five herbicide active ingredients. Inhalation NOAELs are available for all of the herbicide active ingredients, with the exception of rimsulfuron, which has no inhalation NOAELs because of its low toxicity and use pattern. Additionally, aminopyralid and clopyralid do not have long-term NOAELs.

5.2.2 Estimating Potential Exposure for Public Receptors

Exposure assumptions for public receptors are presented in Table 4-5. The equations used to calculate exposure doses are shown below. Additional information is provided for parameters in the equations that have not already been defined. As discussed in Section 3.0, dose-response values are available for short-, intermediate-, and long-term exposures. Short term is defined as up to 30 days, intermediate term is defined as 1 to 6 months, and long term is defined as over 6 months (USEPA 2012a). While it is possible that public receptors use public lands under intermediate- and long-term time frames, it is unlikely that public receptors would be exposed to herbicides under the routine-use scenario for more than a short-term exposure. Therefore, short-term dose-response values are used to evaluate the public receptors under the routine-use exposure scenario. To account for the unlikely possibility that public receptors could repeatedly enter areas that have been recently sprayed, the Uncertainty Analysis (Section 5.4) includes an evaluation of the public receptors under an intermediate- and a long-term exposure scenario.

The application rate for the formulation of 2,4-D used to treat a volume of water is in units of lb a.e./ac-foot. In order to use the application rate in the equations below for accidental exposures, a pond depth of 1 foot was assumed.

5.2.2.1 Dermal Contact with Herbicide Active Ingredient

The following equations are used to evaluate dermal contact with herbicide a.i. by public receptors through spray drift and accidental direct spray.

Spray Drift

$$Dose_{routine}\,(mg/kg-day) = EF_{dp}\,(cm^2/kg-day) * DR\,(mg\,a.i./cm^2) * DAF\,(unitless)$$

Direct Spray

$$Dose_{accident}\,(mg/kg-day) =$$

$$EF_{dp}\,(cm^2/kg-day) * AR\,(lb\,a.i./acre) * CF_1\,(mg/lb) * CF_2\,(acre/cm^2) * DAF\,(unitless)$$

where:

$$EF_{dp}\,(cm^2/kg-day) = \frac{SA\,(cm^2/day)}{BW\,(kg)}$$

and where:

Parameter	Units	Definition
EF_{dp}	cm^2/kg-day	Exposure Factor for dermal pathway (Table 4-5)
DR	mg a.i./cm^2	Herbicide Active Ingredient Deposition Rate due to spray drift (Table 4-8)
AR	lb a.i./acre	Herbicide Active Ingredient Application Rate, direct spray, accidental scenarios (Table 4-1)
SA	cm^2/day	Surface Area of skin exposed (Table 4-5)
DAF	Unitless	Dermal Absorption Factor (Table 4-17)
BW	Kg	Body Weight (Table 4-5)
CF_1	$4.54x10^5$ mg/lb	Conversion Factor used to convert pounds to mg
CF_2	$2.47x10^{-8}$ acre/cm^2	Conversion Factor used to convert acres to cm^2

MOEs are calculated as follows:

Dose	NOAEL Type	MOE Equation
Routine	Dermal - Short-term (ds)	$\frac{NOAEL_{ds}\ (mg/kg-day)}{Dose_{routine}\ (mg/kg-day)}$
Accident	Dermal - Short-term (ds)	$\frac{NOAEL_{ds}\ (mg/kg-day)}{Dose_{accident}\ (mg/kg-day)}$

The short-term dermal NOAELs are presented in Table 3-1. Note that aminopyralid, clopyralid, and fluroxypyr have been identified as not inducing dermal toxicity; therefore, dermal MOEs are not calculated for these herbicide active ingredients.

5.2.2.2 Dermal Contact with Foliage

It is assumed that recreational and residential receptors could be exposed to herbicide active ingredients present on foliage through dermal contact on a lawn (residential) or while hiking (recreational) or berry picking (recreational). The equations for this pathway are based on information provided in USEPA (2012a). Equations used to quantify this potential exposure are as follows:

$$Dose\ (mg/kg-day) = EF_{df}\ (cm^2/kg-day) * DFR\ (mg/cm^2) * DAF$$

where:

$$EF_{df}\ (cm^2/kg-day) = \frac{T_c\ (cm^2/hr) * ET\ (hr/day)}{BW\ (kg)}$$

$$DFR_{routine}\ (mg/cm^2) = DR\ (mg\ a.i./cm^2) * F\ (unitless)$$

$$DFR_{accident}\ (mg/cm^2) = F\ (unitless) * AR\ (lb\ a.i./acre) * CF_1\ (mg/lb) * CF_2\ (acre/cm^2)$$

and where:

Parameter	Units	Definition
EF_{df}	cm^2/kg-day	Exposure Factor for dermal foliage pathway (Table 4-5)
T_c	cm^2/hr	Transfer coefficient (Table 4-5 and described below)
ET	hr/day	Exposure Time (Table 4-5)
BW	kg	Body Weight (Table 4-5)
DFR	mg/cm^2	Dislodgeable Foliar Residue (calculated)
DR	mg a.i./cm^2	Herbicide Active Ingredient Deposition Rate due to spray drift (Table 4-8)
F	unitless	Fraction active ingredient available (described below)
AR	lb a.i./acre	Herbicide Active Ingredient Application Rate direct spray, accidental scenario (Table 4-1)
DAF	unitless	Dermal Absorption Factor (Table 4-17)
CF_1	$4.54x10^5$ mg/lb	Conversion Factor used to convert pounds to mg
CF_2	$2.47x10^{-8}$ acre/cm^2	Conversion Factor used to convert acres to cm^2

MOEs are calculated as follows:

Dose	NOAEL Type	MOE Equation
Routine	Dermal - Short-term (ds)	$\frac{NOAEL_{ds}\ (mg/kg-day)}{Dose_{routine}\ (mg/kg-day)}$
Accident	Dermal - Short-term (ds)	$\frac{NOAEL_{ds}\ (mg/kg-day)}{Dose_{accident}\ (mg/kg-day)}$

Note that aminopyralid, clopyralid, and fluroxypyr have been identified as not inducing dermal toxicity; therefore, dermal MOEs are not calculated for these herbicide active ingredients.

The dermal Tc is used to estimate the amount of herbicide active ingredient that may be transferred from foliage to skin. Transfer coefficients for each receptor were discussed in Section 4.3.3 and are shown in Table 4-5, and were selected based on available guidance and USEPA recommendation (J. Evans, USEPA OPP personal communication, February 9, 2012). The Tcs are summarized below:

- Hiker/Hunter and Angler - 640 cm^2/hour (USEPA 2011b).
- Berry Picker and Native American Adult - 1,100 cm^2/hour (USEPA 2011b).
- Berry Picker and Native American Child - 363 cm^2/hour, based on the adult Tc of 1,100 cm^2/hour (USEPA 2011b) and the calculated child (age 0-6) to adult surface area ratio of 0.33 (USEPA 2012a).
- Residential Adult – 180,000 cm^2/hour (USEPA 2012a).
- Residential Child – 59,400 cm^2/hour, based on the adult Tc of 180,000 cm^2/hour (USEPA 2012a) and the calculated child (age 0-6) to adult surface area ratio of 0.33 (USEPA 2012a).

The fraction active ingredient available for transfer (F) is the fraction of the active ingredient application rate that may be transferred from the lawn or foliage to a human receptor. For the residential lawn scenario, a value of 0.01 is used, based on the information presented in Table 3-3 of USEPA (2012a) for exposure to pesticides on treated lawns as well as USEPA recommendation (J. Evans, USEPA OPP personal communication, February 22, 2011). For the foliage pathway, a value of 0.25 is used, based on information presented in Table 4-5 of USEPA (2012a) for exposure to pesticides in gardens or trees as well as USEPA recommendation (J. Evans, USEPA OPP personal communication, February 22, 2011).

For certain herbicide active ingredients, the dose is calculated by including a DAF in the numerator of the equation to account for dermal absorption when the endpoint is selected from an oral study. As shown in Tables 3-1 and 4-17, the calculation of dermal doses for 2,4-D includes a DAF of 0.1 and the calculation of dermal dose for rimsulfuron includes a DAF of 1. For the other herbicide active ingredients, the USEPA has determined that dermal NOAELs (and therefore DAFs) are not necessary due to low toxicity.

5.2.2.3 Dermal Contact with Water while Swimming

The equation used to estimate a receptor’s potential exposure via dermal contact with surface water is as follows:

$$Dose\ (mg/kg-day) = EF_{dw}\ (cm^2-hr/kg-day) * Kp\ (cm/hr) * C_w\ (mg\ a.i./L) * CF_3\ (L/cm^3)$$

where:

$$EF_{dw}\ (cm^2 - hr/kg - day) = \frac{SA\ (cm^2) * ET(hr/day)}{BW(kg)}$$

and where:

Parameter	Units	Definition
EF_{dw}	cm^2-hr/kg-day	Exposure Factor for dermal water pathway (Table 4-5)
Kp	cm/hr	Permeability Constant for skin (Table 4-17)
C_w	mg a.i./L	Concentration in water (Routine Use, spray drift and runoff - Table 4-12, Direct Spray - Tables 4-13 and 4-14; Accidental Spill - Table 4-15, 4-16)
SA	cm^2	Surface Area of skin exposed (Table 4-5)
BW	kg	Body Weight (Table 4-5)
CF_3	L/1,000 cm^3	Conversion Factor used to convert liters to cm^3

MOEs are calculated as follows:

Dose	NOAEL Type (a)	MOE Equation
Routine	Oral - Short -term (os)	$\frac{NOAEL_{os}\ (mg/kg - day)}{Dose_{routine}\ (mg/kg - day)}$
Accident	Oral - Short -term (os)	$\frac{NOAEL_{os}\ (mg/kg - day)}{Dose_{accident}\ (mg/kg - day)}$

Concentrations in water resulting from spray drift and surface runoff are presented in Table 4-12 for short-, intermediate-, and long-term exposure. As discussed previously, the intermediate- and long-term exposure scenarios are evaluated in the Uncertainty Analysis. The short-term water concentration is used with the short-term NOAEL to derive an MOE for short-term exposure. Water concentrations for the accidental scenarios are presented in Tables 4-13 and 4-14 (direct spray) and 4-15 and 4-16 (accidental spill). These water concentrations are used with the short-term NOAELs to derive MOEs for the accidental scenarios.

The Kps used in this HHRA are described in Section 4.5.2 and presented in Table 4-18.

The accidental spill scenario assumes that 140 gallons of herbicide mix from a helicopter or 200 gallons of herbicide mix from a batch truck are spilled. These amounts are approximately the largest amounts used by the BLM that can be carried in a helicopter and a truck, respectively.

Oral NOAELs are used to evaluate the dermal contact with water pathway because the dermal dose in the equation assumes that the herbicide active ingredient is absorbed into the body. Dermal NOAELs assume that the dose is applied to the skin and that the skin acts as a barrier. Therefore, use of dermal NOAELs with an absorbed dose may result in an underestimation of the amount of herbicide active ingredient absorbed. Although oral NOAELs have not necessarily been adjusted to reflect an absorbed dose, absorption of these herbicide active ingredients is assumed to be much higher via the oral exposure route than the dermal exposure route. Therefore, it is more appropriate to use oral NOAELs for the dermal contact with water pathway. Table 3-1 lists the short- and intermediate-term oral NOAELs for each of the herbicide active ingredients. Short- and intermediate-term oral NOAELs are available for all of the herbicide active ingredients evaluated, with the exception of rimsulfuron.

5.2.2.4 Ingestion of Drinking Water or Swimming Water

The equation used to estimate a receptor's potential exposure via ingestion of drinking water or swimming water is as follows:

$$\text{Dose}\,(\text{mg/kg}-\text{day}) = \text{EF}_{iw}\ (\text{L/kg}-\text{day}) * \text{C}_{w}\ (\text{mg/L})$$

where:

$$\text{EF}_{iw}\ (\text{L/kg}-\text{day}) = \frac{\text{IR}_{w}\ (\text{L/day})}{\text{BW}\,(\text{kg})}$$

and where:

Parameter	Units	Definition
EF_{iw}	L/kg-day	Exposure Factor for ingestion of water pathway (Table 4-5)
IR_{w}	L/day	Ingestion Rate for water (Table 4-5)
C_{w}	mg/L	Concentration in water (Routine Use, spray drift and runoff - Table 4-12; Direct Spray - Tables 4-13 and 4-14; Accidental Spill - Tables 4-15 and 4-16)
BW	kg	Body Weight (Table 4-5)

For incidental ingestion pathways (swimmer), the risk assessment uses the oral NOAELs to calculate MOEs. Oral NOAELs are used rather than PADs because this ingestion is considered incidental rather than dietary. MOEs are calculated as follows:

Dose	NOAEL Type	MOE Equation (Incidental Ingestion of Water)
Routine	Oral - Short-term (os)	$\frac{\text{NOAEL}_{os}\ (\text{mg/kg}-\text{day})}{\text{Dose}_{routine}\ (\text{mg/kg}-\text{day})}$
Accident	Oral - Short -term (os)	$\frac{\text{NOAEL}_{os}\ (\text{mg/kg}-\text{day})}{\text{Dose}_{accident}\ (\text{mg/kg}-\text{day})}$

Table 3-1 lists the short--term oral NOAELs for each of the herbicide a.i.s.

For drinking water pathways (hiker/hunter, berry picker, angler, and Native American), it is more relevant to compare the dose with a PAD and calculate a %PAD. The drinking water pathway represents dietary exposure. The PADs are calculated as follows:

Dose	PAD Type	%PAD Equation (Drinking Water)
Routine	Acute PAD	$\frac{\text{Dose}_{routine}\ (\text{mg/kg}-\text{day})}{\text{PAD}_{acute}\ (\text{mg/kg}-\text{day})} * 100\%$
Accident	Acute PAD	$\frac{\text{Dose}_{accident}\ (\text{mg/kg}-\text{day})}{\text{PAD}_{acute}\ (\text{mg/kg}-\text{day})} * 100\%$

Table 3-1 lists acute and chronic PADs for the five herbicide a.i.s. The acute PAD was used for the accidental and short-term routine exposure scenarios. The USEPA has developed acute PADs for clopyralid and 2,4-D. Chronic PADs are available for all five herbicide a.i.s.

Concentrations in water due to spray drift and runoff are presented in Table 4-12 for short-, intermediate-, and long-term exposure. As discussed previously, the intermediate- and long-term exposure scenarios are evaluated in the Uncertainty Analysis. The short-term water concentration is used with the short-term NOAEL to derive an MOE for short-term swimming exposure and with the acute PAD to derive a %PAD for the short-term drinking water pathway. Water concentrations for the accidental scenarios are presented in Tables 4-13 and 4-14 (direct spray) and 4-15 and 4-16 (accidental spill). These water concentrations are used with the short-term NOAELs to derive MOEs for the accidental swimming scenarios and with the acute PADs to derive %PADs for the accidental drinking water scenarios.

5.2.2.5 Ingestion of Fish

A recreational angler or a Native American receptor may ingest fish that have bioaccumulated herbicide a.i.s present in surface water. The equation used to estimate a receptor's potential exposure via fish ingestion is as follows:

$$\text{Dose}\,(\text{mg/kg}-\text{day}) = EF_{fi}\,(\text{mg/kg}-\text{day}) * C_w\,(\text{mg/L}) * BCF\,(\text{L/kg}) * CF_4\,(\text{kg/mg})$$

where:

$$EF_{fi}\,(\text{mg/kg}-\text{day}) = \frac{IR_f\,(\text{mg/day})}{BW(\text{kg})}$$

And where:

Parameter	Units	Definition
EF_{fi}	mg/kg-day	Exposure Factor for fish ingestion pathway (Table 4-5)
IR_f	mg/day	Ingestion Rate for fish (Table 4-5)
C_w	mg/L	Concentration in water (Routine Use, spray drift and runoff - Table 4-12; Direct Spray - Tables 4-13 and 4-14, Accidental Spill - Tables 4-15 and 4-16)
BCF	L/kg	Bioconcentration Factor (Table 4-19)
BW	kg	Body Weight (Table 4-5)
CF_4	10^{-6} kg/mg	Conversion Factor used to convert mg to kg

PADs are calculated as follows:

Dose	PAD Type	%PAD Equation
Routine	acute PAD	$\frac{\text{Dose}_{routine}\,(\text{mg/kg}-\text{day})}{\text{PAD}_{acute}\,(\text{mg/kg}-\text{day})} * 100\%$
Accident	acute PAD	$\frac{\text{Dose}_{accident}\,(\text{mg/kg}-\text{day})}{\text{PAD}_{acute}\,(\text{mg/kg}-\text{day})} * 100\%$

The BCF is defined as the ratio of chemical concentration in the organism to that in surrounding water. Bioconcentration occurs through uptake and retention of a substance from water only, through gill membranes or other external body surfaces. The BCFs for each of the herbicide active ingredients have been estimated based on information from the literature, and are discussed in Section 4.5.3. The BCFs are presented in Table 4-19.

Table 3-1 lists acute and chronic PADs for the five herbicide active ingredients. The acute PAD was used for the accidental and short-term routine exposure scenarios. The USEPA has developed acute PADs for clopyralid and 2,4-D. Chronic PADs are available for all five herbicide active ingredients.

Concentrations in water are presented in Table 4-12 for short-, intermediate-, and long-term exposure due to spray drift and runoff. As discussed previously, the intermediate- and long-term exposure scenarios are evaluated in the Uncertainty Analysis. The short-term water concentration is used with the acute PAD to derive a %PAD for short-term exposure. Water concentrations for the accidental scenarios are presented in Tables 4-13 and 4-14 (direct spray) and 4-15 and 4-16 (accidental spill). These water concentrations are used with the acute PADs to derive %PADs for the accidental scenarios.

5.2.2.6 Ingestion of Berries

It is assumed that the berry picker and Native American receptor could be exposed to herbicide a.i.s through berry ingestion. None of the USEPA pesticide documents specifically list an equation for evaluating berry or other food ingestion. This exposure pathway is likely to represent an acute episodic event due to the unlikelihood of people ingesting berries that have recently been sprayed or impacted by spray drift. However, to provide a conservative estimate of potential risks, an equation for toddler ingestion of pesticide-treated grass (USEPA 2002) was modified to evaluate the berry ingestion pathway. This equation was used to evaluate ingestion of berries:

$$\text{Dose}\,(\text{mg}/\text{kg}-\text{day}) = \text{BR}\,(\text{mg}/\text{cm}^2) * \text{EF}_{\text{bi}}\,(\text{cm}^2/\text{kg}-\text{day})$$

where:

$$\text{EF}_{\text{bi}}\,(\text{cm}^2/\text{kg}-\text{day}) = \frac{\text{IR}_{\text{b}}\,(\text{cm}^2/\text{day})}{\text{BW}\,(\text{kg})}$$

$$\text{BR}_{\text{routine}}\,(\text{mg}/\text{cm}^2) = \text{DR}\,(\text{mg}/\text{cm}^2) * \text{F}$$

$$\text{BR}_{\text{accident}}\,(\text{mg}/\text{cm}^2) = \text{AR}\,(\text{lb a.i.}/\text{acre}) * \text{F} * \text{CF}_1\,(\text{mg}/\text{lb}) * \text{CF}_2\,(\text{acre}/\text{cm}^2)$$

and where:

Parameter	Units	Definition
EF_{bi}	cm^2/kg-day	Exposure Factor for berry ingestion pathway (Table 4-5)
IR_b	cm^2/day	Ingestion Rate for berries (Table 4-5)
BR	mg/cm^2	Berry Residue (calculated)
DR	mg/cm^2	Herbicide Active Ingredient Deposition Rate due to spray drift (Table 4-8)
AR	lb a.i./acre	Herbicide Active Ingredient Application Rate, direct spray accidental scenarios (Table 4-5)
F	unitless	Fraction a.i. available on berry (discussed below)
BW	kg	Body Weight (Table 4-5)
CF_1	4.54×10^5 mg/lb	Conversion Factor to convert pounds to mg
CF_2	2.47×10^{-8} acre/cm^2	Conversion Factor to convert acres to cm^2

PADs are calculated as follows:

Dose	PAD Type	%PAD Equation
Routine	acute PAD	$\frac{Dose_{routine}\ (mg/kg-day)}{PAD_{acute}\ (mg/kg-day)} * 100\%$
Accident	acute PAD	$\frac{Dose_{accident}\ (mg/kg-day)}{PAD_{acute}\ (mg/kg-day)} * 100\%$

The fraction active ingredient retained on the berry (F) is assumed to be 1 (J. Evans, USEPA OPP personal communication, February 21, 2012).

The equation presented in USEPA (2002) for toddler grass ingestion uses an ingestion rate of 25 cm^2/day assuming that a child eats a handful of grass (2 inch x 2 inch). Therefore, it was necessary to convert the berry ingestion rates presented in Section 4.3.3.6 and Table 4-5 of 320 g/day (adult) and 60 g/day to a berry ingestion rates in units of cm^2/day. The conversion required a surface area (cm^2) to weight (mg) of berry ratio. Cheung and Yen (1996) calculated a surface area to weight ratio of 2 cm^2/g for Thompson seedless grapes. This value was used to estimate the berry ingestion rate in units of cm^2/day. It was assumed that herbicide active ingredients deposit only on the top half of a berry. Therefore, half of the surface area was used in the equation. The following equation was used to convert the berry ingestion rates from units of g/day to units of cm^2/day:

$$\text{Ingestion rate}\,(cm^2/day) = \text{Ingestion rate}\,(g/day) * (2\,cm^2/g) * 0.5$$

Based on the above equation, the adult berry ingestion rate is 320 cm^2/day and the child berry ingestion rate is 60 cm^2/day. Table 3-1 lists acute and chronic PADs for the five herbicide active ingredients. As discussed previously, the intermediate- and long-term exposure scenarios are evaluated in the Uncertainty Analysis. The acute PAD was used for the accidental and short-term routine exposure scenarios. The USEPA has developed acute PADs for clopyralid and 2,4-D. Chronic PADs are available for all five herbicide active ingredients.

5.3 Results of Risk Characterization

Using the equations provided above, %PADs and MOEs were calculated for each of the herbicide active ingredients for individual receptors. Some of the herbicide active ingredients lacked specific PADs and NOAELs; therefore, it was not possible to conduct risk calculations for all exposure pathways and herbicide active ingredients. For the accidental scenarios, it was assumed that a receptor is exposed via one accidental exposure pathway; therefore, the accidental risks from different scenarios were not added together. For the routine-use scenarios, it was assumed that a receptor could be exposed to a specific herbicide active ingredient through several exposure pathways. Therefore, ARIs were calculated for routine-use scenarios. The risk characterization results for the occupational and public receptors are discussed separately.

5.3.1 Occupational Receptors

For occupational receptors, separate calculations were conducted for routine-use typical application rate scenarios, routine-use maximum application rate scenarios, and accidental scenarios. For the routine-use scenarios, exposure through dermal and inhalation exposures were evaluated (provided appropriate information was available for the specific herbicide active ingredient). In the current USEPA OPP program, short-term is defined as up to 30 days, intermediate-term is defined as 1 to 6 months, and long-term is defined as greater than 6 months (USEPA 2012a). The accidental scenario evaluated exposure through dermal absorption of an accidental spill of liquid to worker skin. The risk calculation spreadsheets are shown in Appendix B. The results for each herbicide active ingredient are summarized below.

5.3.1.1 Aminopyralid

Aminopyralid is proposed for use on rangeland, public-domain forestland, energy and mineral sites, rights-of-way, and recreation and cultural sites. Aminopyralid may be applied by airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), or backpack (spot applications). Therefore, potential occupational receptors include pilots, applicators, mixer/loaders, and combined applicator/mixer/loaders. Table 5-2 shows the summary risk results for occupational exposure to aminopyralid.

Routine-use ARIs were calculated for inhalation exposures to occupational receptors under both typical and maximum application rate scenarios. As discussed in Section 2.2.1.1, dermal NOAELs are not available for aminopyralid, and the USEPA (2009a) has determined that aminopyralid is either not absorbed or poorly absorbed through the skin and that development of dermal NOAELs is not necessary. Additionally, the USEPA (2009a) has not developed a long-term inhalation NOAEL for aminopyralid. In a personal communication (J. Evans, USEPA OPP personal communication, February 28, 2011), the USEPA noted that since there is no exposure scenario that corresponds to seasonal exposures, such as those associated with BLM herbicide applications, long-term exposure is not of concern. Therefore, the short- and intermediate-term ARIs are based on the inhalation pathway, and a long-term ARI was not calculated. Routine-use ARIs for aminopyralid are greater than 1 under typical and maximum application rate scenarios, indicating no exceedance of the USEPA's level of concern for occupational receptors. Appendix B provides the intermediate calculations and the MOE values.

Aminopyralid is present in a liquid formulation. Therefore, the accidental exposure scenario assumes that the concentrated herbicide active ingredient is spilled directly onto an occupational receptor. However, as discussed above, there is no evidence that aminopyralid is toxic via the dermal route of exposure, and dermal NOAELs have not been identified. Therefore, although spill concentrations were calculated, an accidental scenario ARI was not calculated.

In summary, these results show that potential risks associated with exposure to aminopyralid are not expected to exceed the USEPA's level of concern for any of the occupational receptors under the scenarios evaluated and that no adverse health effects are expected.

5.3.1.2 Clopyralid

Clopyralid is currently used on rangeland, public-domain forestland, energy and mineral sites, rights-of-way, and recreation and cultural sites. Clopyralid may be applied by airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), or backpack (spot applications). Therefore, potential occupational receptors include pilots, applicators, mixer/loaders, and combined applicator/mixer/loaders. Table 5-3 shows the summary risk results for occupational exposure to clopyralid.

Routine-use ARIs were calculated for inhalation exposures to occupational receptors under typical and maximum application rate scenarios. As discussed in Section 2.2.2.2, dermal NOAELs are not available for clopyralid, and the USEPA (2009b) has determined that dermal absorption of clopyralid is low and that potential risks from dermal exposures are not of concern. The USEPA has not developed a long-term inhalation NOAEL for clopyralid. In a personal communication (J. Evans, USEPA OPP personal communication, February 28, 2011), the USEPA noted that since there is no exposure scenario that corresponds to seasonal exposures, such as those associated with BLM herbicide applications, long-term exposure is not of concern. Therefore, the short- and intermediate-term ARIs are based on the inhalation pathway, and a long-term ARI was not calculated. Routine-use ARIs for clopyralid are greater than 1 under typical and maximum application rate scenarios, indicating no exceedance of the USEPA's level of concern for occupational receptors. Appendix B provides the intermediate calculations and the MOE values.

Clopyralid is present in a liquid formulation. Therefore, the accidental exposure scenario assumes that the concentrated herbicide active ingredient is spilled directly onto an occupational receptor. However, as discussed above, there is no evidence that clopyralid is toxic via the dermal route of exposure, and dermal NOAELs have not been identified. Therefore, although spill concentrations were calculated, an accidental scenario ARI was not calculated.

In summary, these results show that risks associated with exposure to clopyralid are not expected to exceed the USEPA's level of concern for any of the occupational receptors under the scenarios evaluated and that no adverse health effects are expected.

5.3.1.3 2,4-D

2,4-D, in its various formulations, is currently used on rangeland, public-domain forestland, energy and mineral sites, rights-of-way, and recreation, cultural, and aquatic sites. 2,4-D may be applied by airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), backpack (spot applications), or boat (boom/broadcast or spot applications). Therefore, potential occupational receptors include pilots, applicators, mixer/loaders, and combined applicator/mixer/loaders. Routine-use ARIs were calculated for occupational receptors for dermal and inhalation exposures under typical and maximum application rate scenarios. ARIs for the various formulations are discussed below. Appendix B provides the intermediate calculations and the MOE values.

Terrestrial - Annual/Perennial Species (Liquid Formulation)

Table 5-4 presents the summary risk results for occupational exposure to a liquid formulation of 2,4-D during a treatments of annual and perennial species in terrestrial environments. Under the typical application rate scenario for short- and intermediate-term exposures, ARIs are above 1, indicating no exceedance of the USEPA's level of concern. Under the typical application rate long-term exposure scenario, the ARI is slightly below 1 for the following scenario:

- Airplane Mixer/Loader – long-term exposure

Under the maximum application rate scenario, ARIs are below 1 for 7 of the 54 scenarios evaluated, indicating an exceedance of the USEPA's level of concern under the following scenarios:

- Airplane Mixer/Loader – short-, intermediate-, and long-term exposure.
- Helicopter Mixer/Loader – long-term exposure.
- Backpack Applicator/Mixer/Loader – long-term exposure (note the ARI is only slightly below 1).
- Horseback Applicator/Mixer/Loader – intermediate- and long-term exposure.

Since there is no long-term exposure scenario that corresponds to seasonal exposures, such as those associated with BLM herbicide applications, long-term exposure is not applicable. However, since long-term NOAEL values were available for both dermal and inhalation exposure routes, long-term exposures for 2,4-D were included in the risk assessment. If these long-term scenarios are not considered, only 3 of the 54 maximum application rate scenarios exceed the USEPA's level of concern.

This formulation of 2,4-D is liquid. Therefore, the accidental exposure scenario assumes that the concentrated herbicide active ingredient is spilled directly onto an occupational receptor. For this scenario, it was assumed that dermal and inhalation exposure would occur even if proper PPE was being used. This same scenario is applied to all of the receptors evaluated. As indicated in Table 5-4, the ARI for a scenario involving accidental spill of concentrated liquid is below 1 for all occupational receptors evaluated, indicating an exceedance of the USEPA's level of concern. To further evaluate the potential risks to occupational receptors under an accidental spill scenario, concentrations of the herbicide active ingredient in a mixed solution were also calculated for the typical and maximum and application rates, as shown in Table 4-7. The concentrations were calculated assuming the lowest spray rate (helicopter, 5 gallons per acre). As indicated in Table 5-4, the ARI for the accidental spill of mixed solution scenario is below 1 for both typical and maximum application rates, indicating an exceedance of the USEPA's level of concern and a potential concern for human health for all occupational receptors evaluated.

Terrestrial - Woody Species (Liquid Formulation)

Table 5-5 presents the summary risk results for occupational exposure to a liquid formulation of 2,4-D used to treat woody species in terrestrial environments. Under the typical application rate scenario for short- and intermediate-term exposures, ARIs are above 1, indicating no exceedance of the USEPA's level of concern. Under the typical application rate scenario long-term exposure scenario, ARIs are below 1 for 2 of the 54 scenarios evaluated:

- Airplane Mixer/Loader – long-term exposure.
- Horseback Applicator/Mixer/Loader – long-term exposure.

Under the maximum application rate scenario, ARIs are below 1, indicating an exceedance of the USEPA's level of concern, for 12 of the 54 scenarios evaluated:

- Airplane Pilot – long-term exposure.
- Airplane Mixer/Loader – short-, intermediate-, and long-term exposure.
- Helicopter Mixer/Loader – intermediate- and long-term exposure.
- Backpack Applicator/Mixer/Loader – long-term exposure.
- Horseback Applicator/Mixer/Loader – short-, intermediate- and long-term exposure.
- Truck Mount Spot Applicator – long-term exposure.
- Truck Mount Spot Applicator/Mixer/Loader – long-term exposure.

As noted above, long-term exposure scenarios for 2,4-D were included in the risk assessment, even though long-term exposure is not applicable. If the long-term scenarios are not considered, none of the typical application rate scenarios exceed the USEPA's level of concern, and only 5 of the 54 maximum application rate scenarios exceed the USEPA's level of concern.

This formulation of 2,4-D is liquid. Therefore, the accidental scenario assumes that the concentrated herbicide active ingredient is spilled directly onto an occupational receptor, and assumes that the use of proper PPE does not prevent dermal exposure. This same scenario is applied to all of the receptors evaluated. As indicated in Table 5-5, the ARI for an exposure scenario involving an accidental spill of concentrated liquid is below 1 for all occupational receptors evaluated, indicating an exceedance of the USEPA's level of concern. To further evaluate the potential risks to occupational receptors under an accidental spill scenario, concentrations of the herbicide active ingredient in a mixed solution were also calculated for the typical and maximum application rates, as shown in Table 4-7. The concentrations were calculated assuming the lowest spray rate (helicopter, 5 gallons per acre). As indicated in Table 5-5, the ARI for the accidental spill of mixed solution scenario is below 1 for both typical and maximum application rates, indicating an exceedance of the USEPA's level of concern and a potential concern for human health for all occupational receptors evaluated.

Aquatic - Treatment of Floating and Emerged Vegetation (Liquid Formulation)

Table 5-6 presents the summary risk results for occupational exposure to a liquid formulation of 2,4-D used to treat floating and emerged vegetation in aquatic environments. Under the typical application rate scenario for short- and intermediate-term exposures, ARIs are above 1, indicating no exceedance of the USEPA's level of concern. Under the typical application rate scenario long-term exposure scenario, ARIs are below 1 for 2 of the 72 scenarios evaluated:

- Airplane Mixer/Loader – long-term exposure.
- Horseback Applicator/Mixer/Loader – long-term exposure.

Under the maximum application rate scenario, ARIs are below 1, indicating an exceedance of the USEPA's level of concern, for the following 14 of 72 scenarios evaluated:

- Airplane Pilot – long-term exposure.
- Airplane Mixer/Loader – short-, intermediate-, and long-term exposure.
- Helicopter Mixer/Loader – intermediate- and long-term exposure.
- Backpack Applicator/Mixer/Loader – long-term exposure.
- Horseback Applicator/Mixer/Loader – short-, intermediate-, and long-term exposure.
- Truck Mount Spot Applicator – long-term exposure.
- Truck Mount Spot Applicator/Mixer/Loader – long-term exposure.
- Boat Spot Applicator – long-term exposure.
- Boat Spot Applicator/Mixer/Loader – long-term exposure.

As noted above, long-term exposure scenarios for 2,4-D were included in the risk assessment, even though long-term exposure is not of concern. If the long-term scenarios are not considered, none of the typical application rate scenarios exceed the USEPA's level of concern, and only 5 of the 72 maximum application rate scenarios exceed the USEPA's level of concern.

This formulation of 2,4-D is liquid. Therefore, the accidental scenario assumes that the concentrated herbicide active ingredient is spilled directly onto an occupational receptor, and assumes that the use of proper PPE does not prevent dermal exposure. This same scenario is applied to all of the receptors evaluated. As indicated in Table 5-6, the ARI for an exposure scenario involving the accidental spill of concentrated liquid is below 1 for all occupational receptors evaluated, indicating an exceedance of the USEPA's level of concern. To further evaluate the potential risks to occupational receptors under an accidental spill scenario, concentrations of the herbicide active ingredient in a mixed solution were also calculated for the typical and maximum application rates, as shown in Table 4-7. The concentrations were calculated assuming the lowest spray rate (helicopter, 5 gallons per acre). As indicated in Table 5-6, the ARI for the accidental spill of mixed solution scenario is below 1 for both typical and maximum application rates, indicating an exceedance of the USEPA's level of concern and a potential concern for human health for all occupational receptors evaluated.

Aquatic - Treatment of Submerged Vegetation (Volume of Water, Liquid Formulation)

Table 5-7 presents the summary risk results for occupational exposure to a liquid formulation of 2,4-D used to treat submerged vegetation in a volume of water in aquatic environments. Under the typical application rate scenario, ARIs are below 1, indicating an exceedance of the USEPA's level of concern, for 7 of the 72 scenarios evaluated:

- Airplane Mixer/Loader – short-, intermediate-, and long-term exposure.
- Helicopter Mixer/Loader - long-term exposure.
- Horseback Applicator/Mixer/Loader – short-, intermediate-, and long-term exposure.

Under the maximum application rate scenario, ARIs are below 1, indicating an exceedance of the USEPA's level of concern, for 25 of the 72 scenarios evaluated:

- Airplane Pilot – intermediate- and long-term exposure.
- Airplane Mixer/Loader – short-, intermediate-, and long-term exposure.

- Helicopter Pilot – long-term exposure.
- Helicopter Mixer/Loader – short-, intermediate-, and long-term exposure.
- Backpack Applicator/Mixer/Loader – short-, intermediate-, and long-term exposure.
- Horseback Applicator/Mixer/Loader – short-, intermediate-, and long-term exposure.
- ATV Spot Applicator – long-term exposure.
- ATV Spot Applicator/Mixer/Loader – long-term exposure.
- Truck-Mount Spot Applicator – intermediate- and long-term exposure.
- Truck-Mount Spot Applicator/Mixer/Loader – intermediate- and long-term exposure.
- Boat Spot Applicator – intermediate- and long-term exposure.
- Boat Spot Applicator/Mixer/Loader – intermediate- and long-term exposure.

If the long-term scenarios are not considered, only 4 of the 72 typical application rate scenarios exceed the USEPA's level of concern, and only 13 of the 72 maximum application rate scenarios exceed the USEPA's level of concern.

This formulation of 2,4-D is liquid. Therefore, the accidental scenario assumes that the concentrated herbicide active ingredient is spilled directly onto an occupational receptor, and assumes that the use of proper PPE does not prevent dermal exposure. This same scenario is applied to all of the receptors evaluated. As indicated in Table 5-7, the ARI for an exposure scenario involving the accidental spill of concentrated liquid is below 1 for all occupational receptors evaluated, indicating an exceedance of the USEPA's level of concern. To further evaluate the potential risks to occupational receptors under an accidental spill scenario, concentrations of the herbicide active ingredient in a mixed solution were also calculated for the typical and maximum application rates, as shown in Table 4-7. The concentrations were calculated assuming the lowest spray rate (helicopter, 5 gallons per acre). As indicated in Table 5-7, the ARI for the accidental spill of mixed solution scenario is below 1 for both typical and maximum application rates, indicating an exceedance of the USEPA's level of concern and a potential concern for human health for all occupational receptors evaluated.

Aquatic - Treatment of Submerged Vegetation (Pond Bottom, Granular Formulation)

Table 5-8 presents the summary risk results for occupational exposure to a granular formulation of 2,4-D used to treat vegetation on a pond bottom. These treatments are conducted using a granular formulation of 2,4-D that utilizes a special heat-treated attaclay granule carrier, which allows for the granule to drop to the bottom of the pond following application. ARIs are above 1 for all scenarios, indicating no exceedance of the USEPA's level of concern for occupational receptors under routine-use exposure scenarios.

Because the granular form of 2,4-D is not mixed with water prior to application, there is no opportunity for a spill of this formulation to worker skin, and the accidental spill of liquid to worker skin scenario is not applicable.

5.3.1.4 Fluroxypyr

Fluroxypyr is proposed for use on rangeland, public-domain forestland, energy and mineral sites, rights-of-way, and recreation and cultural sites. Fluroxypyr may be applied by airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), or backpack (spot applications). Therefore, potential occupational receptors include pilots, applicators, mixer/loaders, and combined applicator/mixer/loaders. Table 5-9 shows the summary risk results for occupational exposure to fluroxypyr.

Routine-use ARIs were calculated for inhalation exposures to occupational receptors under typical and maximum application rate scenarios. As discussed in Section 2.2.4.1, dermal NOAELs are not available for fluroxypyr, and there are no concerns for developmental or neurological toxicity (USEPA 2007). Therefore, the short-, intermediate-, and long-term ARIs are based on the inhalation pathway. Routine-use ARIs for fluroxypyr are greater than 1 under the typical and maximum application rate scenarios, indicating no exceedance of the USEPA's level of concern for occupational receptors. Appendix B provides the intermediate calculations and the MOE values.

Fluroxypyr is available in a liquid formulation. Therefore, the accidental scenario assumes that the concentrated herbicide active ingredient is spilled directly onto an occupational receptor. However, as discussed above, there is no evidence that fluroxypyr is toxic via the dermal route of exposure, and dermal NOAELs have not been identified. Therefore, although spill concentrations were calculated, an accidental scenario ARI was not calculated.

In summary, these results show that risks associated with exposure to fluroxypyr are not expected to exceed the USEPA's level of concern for any of the occupational receptors under the scenarios evaluated, and that no adverse health effects are expected.

5.3.1.5 Rimsulfuron

Rimsulfuron is proposed for use on rangeland, public-domain forestland, energy and mineral sites, rights-of-way, and recreation and cultural sites. Note that for rangeland and public-domain forestland, the typical application rate is 0.0469 lb a.i./acre and the maximum application rate is 0.0625 lb a.i./acre. For energy and minerals sites, recreation and cultural sites, and rights-of-way, the typical and maximum application rates are the same (0.0625 lb a.i./acre). Therefore, the typical application rate scenario is applicable to rangeland and public-domain forestland, and the maximum application rate scenario is applicable to all five land programs. Rimsulfuron may be applied by airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), or backpack (spot applications). Therefore, potential occupational receptors include pilots, applicators, mixer/loaders, and combined applicator/mixer/loaders. Table 5-10 shows the summary risk results for occupational exposure to rimsulfuron.

Routine-use ARIs were calculated for dermal and inhalation exposures to occupational receptors under typical and maximum application rate scenarios for short-and intermediate-term exposures. As discussed in Section 2.2.5.2, the USEPA (2011c) has not developed long-term dermal or inhalation NOAELs for rimsulfuron. Therefore, while exposure point concentrations were calculated, ARIs were not calculated for occupational receptors under the long-term scenario. Furthermore, long-term exposure is not applicable to seasonal exposures. Routine-use ARIs for rimsulfuron are greater than 1 under the typical and maximum application rate scenarios for short- and intermediate-term exposures, indicating no exceedance of the USEPA's level of concern for occupational receptors. Appendix B provides the intermediate calculations and the MOE values.

Rimsulfuron is present as a dry flowable granule that must be mixed with water prior to application. Therefore, the accidental exposure scenario assumes that the mixed solution is spilled directly onto an occupational receptor, and assumes that the use of proper PPE does not prevent dermal exposure. This same scenario is applied to all of the receptors evaluated. As indicated in Table 5-10, the ARI for an exposure scenario involving the accidental spill of mixed solution is below 1 (based on both the maximum and the typical application rate), indicating an exceedance of the USEPA's level of concern and a potential concern for human health for all occupational receptors evaluated.

In summary, these results show that risks associated with exposure to rimsulfuron are not expected to exceed the USEPA's level of concern for any of the occupational receptors under the routine-use scenarios evaluated, and that no adverse health effects are expected. However, potential risks were identified for the accidental spill of solution to worker skin scenario.

5.3.2 Public Receptors

The following public receptors were evaluated for potential exposure to herbicide active ingredients under both routine (typical and maximum application rate) and accidental exposure scenarios:

- Angler
- Berry Picker - Adult

- Berry Picker - Child
- Hiker/Hunter
- Native American - Adult
- Native American - Child
- Nearby Resident - Adult
- Nearby Resident - Child
- Swimmer - Adult
- Swimmer - Child

Table 4-4 lists the exposure pathways through which each receptor could potentially be exposed to herbicide active ingredients, and Section 4.3 describes the receptors. The routine-use scenarios assume that public receptors are potentially exposed to media impacted by spray drift, while the accidental scenarios assume that receptors are potentially exposed to media that have been directly sprayed by herbicide active ingredient applications. While it is possible that public receptors use public lands for intermediate- and long-term time frames, it is unlikely that public receptors would be exposed to herbicides under the routine-use scenario for more than a short-term exposure, which is defined as up to 30 days (USEPA 2012a). Therefore, only short-term exposures are evaluated in the sections that follow. An evaluation of the public receptors under an intermediate- and a long-term exposure scenario is included in the Uncertainty Analysis (Section 5.4).

Based on the information presented above, public receptors may be impacted by spray drift under routine-use scenarios for the following applications:

- Aerial - plane
- Aerial - helicopter
- Boom/broadcast (truck, ATV/UTV, or boat); both low- and high-boom scenarios

Because spot applications are small and focused, and very little if any spray drift is generated, it is assumed that public receptors would not be impacted by spray of herbicide active ingredients the following applications during routine use of public lands:

- Backpack
- Horseback
- ATV/UTV - spot
- Truck - spot
- Boat - spot

Public receptors may be impacted by direct spray under accidental scenarios for all the application methods.

Appendix B presents the risk calculation spreadsheets. The results are summarized below.

5.3.2.1 Aminopyralid

Aminopyralid is proposed for use on rangeland, public-domain forestland, energy and mineral sites, rights-of-way, and recreational and cultural sites. Aminopyralid may be applied using the following vehicles and methods: airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications). All public receptors are assumed to be potentially exposed to aminopyralid spray drift resulting from aerial applications from airplanes or helicopters, and boom/broadcast (both low-boom and high-boom) application methods from trucks or ATV/UTVs. As noted above, spot applications are small and focused, and very little if any spray drift is generated, it is assumed that public would not be impacted by spray from spot applications.

Under the routine-use scenarios, it is assumed that public receptors are exposed to spray drift via dermal contact, incidental ingestion, and dietary exposure pathways. Both the typical and maximum application rates are considered (see

Table 4-1). The ARIs combine all the exposure estimates to derive a cumulative effect ARI. The short-term routine-use scenario ARIs for aminopyralid are presented in Table 5-11. As discussed in previous sections, the USEPA (2009a) has concluded that aminopyralid is either not absorbed or poorly absorbed through the skin and that development of dermal NOAELs is not necessary, and has not derived an acute PAD for aminopyralid. Therefore, short-term ARIs are based on incidental oral exposure (calculated only for swimming pathways). Short-term routine-use scenario ARIs for aminopyralid are greater than 1 under the typical and maximum application rate scenarios for all public receptors, indicating no exceedance of the USEPA's level of concern under the scenarios evaluated.

The accidental scenario assumes that public receptors are exposed directly to maximum herbicide active ingredient application rates (as shown on Table 4-1) via dermal contact (direct spray of receptor, contact with directly sprayed vegetation, and contact with directly sprayed water), incidental ingestion of water while swimming, or dietary exposure pathways (drinking water, berry ingestion, and fish ingestion). The accidental scenario for a pond assumes that receptors swim in or obtain drinking water from a pond that has been directly sprayed with an herbicide active ingredient or that has received a spill (from a truck or helicopter). Cumulative accidental ARIs were not calculated, as it is assumed that each receptor would be accidentally exposed via only one potential exposure pathway. The accidental scenario ARIs are presented in Table 5-12. Because acute dietary and dermal toxicity values are not available, accidental scenario ARIs for aminopyralid were calculated only for incidental oral pathways (swimming). The ARIs for the swimming pathways are greater than 1, indicating no exceedance of the USEPA's level of concern under the scenarios evaluated.

In summary, these results show that aminopyralid risks are not expected to exceed the USEPA's level of concern for any of the public receptors under the scenarios evaluated and that no adverse health effects are expected.

5.3.2.2 Clopyralid

Clopyralid is currently used on rangeland, public-domain forestland, energy and mineral sites, rights-of-way, and recreational and cultural sites. Clopyralid may be applied using the following vehicles and methods: airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications). All public receptors are assumed to be potentially exposed to clopyralid spray drift resulting from aerial applications from airplanes or helicopters, and boom/broadcast (both low-boom and high-boom) application methods from trucks or ATVs/UTVs. As noted above, spot applications are small and focused, and very little if any spray drift is generated; therefore, public receptors are not assumed to be impacted by herbicide active ingredient spray from spot applications.

The routine-use scenarios assumed that public receptors are exposed to spray drift via dermal contact, incidental ingestion, and dietary exposure pathways. Both the typical and maximum application rates are considered (see Table 4-1). The ARIs combine all the exposure estimates to derive a cumulative effect ARI. The short-term routine-use scenario ARIs for clopyralid are presented in Table 5-13. As discussed previously, no dermal NOAELs are available, and the USEPA (2009b) has concluded that dermal absorption of clopyralid is low and that potential risks from dermal exposures are not of concern. Therefore, short-term ARIs are based on incidental oral exposure and acute dietary exposure. Short-term routine-use scenario ARIs for clopyralid are greater than 1 under the typical and maximum application rate scenarios for all public receptors, indicating no exceedance of the USEPA's level of concern under the scenarios evaluated.

The accidental scenario assumes that public receptors are exposed directly to maximum herbicide active ingredient application rates (as shown on Table 4-1) via dermal contact (direct spray of receptor, contact with directly sprayed vegetation, and contact with directly sprayed water), incidental ingestion of water while swimming, or dietary exposure pathways (drinking water, berry ingestion, and fish ingestion). The accidental scenario for a pond assumes that receptors swim in or obtain drinking water from a pond that has been directly sprayed with an herbicide active ingredient or that has received a spill (from a truck or helicopter). Cumulative accidental ARIs were not calculated, as it is assumed that each receptor would be accidentally exposed via only one potential exposure pathway. The accidental scenario ARIs are presented in Table 5-14. Because acute dietary and dermal toxicity values are not available, accidental scenario ARIs for clopyralid were calculated only for incidental oral pathways (swimming). The ARIs for the swimming pathways are greater than 1, indicating no exceedance of the USEPA's level of concern under the scenarios evaluated and that no adverse health effects are expected.

In summary, these results show that clopyralid risks are not expected to exceed the USEPA's level of concern for any of the public receptors under the scenarios evaluated and that no adverse health effects are expected.

5.3.2.3 2,4-D

2,4-D, in its various formulations, is currently used on rangeland, public-domain forestland, energy and mineral sites, rights-of-way, recreation and cultural sites, and aquatic sites. 2,4-D may be applied using the following vehicles and methods: airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), backpack (spot applications), and boat (boom/broadcast or spot applications). All public receptors are assumed to be potentially exposed to 2,4-D spray drift resulting from aerial applications from airplanes or helicopters and boom/broadcast (both low-boom and high-boom) application methods from trucks, ATVs/UTVs, or boats. As noted above, spot applications are small and focused, and very little if any spray drift is generated; therefore, public receptors are not assumed to be impacted by herbicide active ingredient spray from spot applications.

The routine-use scenarios assumes that public receptors are exposed to spray drift via dermal contact, incidental ingestion, and dietary exposure pathways. Both the typical and maximum application rates are considered (see Table 4-1). The ARIs combine all the exposure estimates to derive a cumulative effect ARI.

The accidental scenario assumes that public receptors are exposed directly to maximum herbicide active ingredient application rates (as shown on Table 4-1) via dermal contact (direct spray of receptor, contact with directly sprayed vegetation, and contact with directly sprayed water), incidental ingestion of water while swimming, or dietary exposure pathways (drinking water, berry ingestion, and fish ingestion). The accidental scenario for a pond assumes that receptors swim in or obtain drinking water from a pond that has been directly sprayed with an herbicide active ingredient or that has received a spill (from a truck or helicopter). Cumulative accidental ARIs were not calculated, as it is assumed that each receptor would be accidentally exposed via only one potential exposure pathway.

The results for the various formulations and uses are presented below.

<u>Terrestrial - Annual/Perennial Species</u>

Table 5-15 presents the summary risk results under the short-term routine-use exposure scenario for public exposure to 2,4-D used to treat annual and perennial species in terrestrial environments. Under scenarios involving applications of 2,4-D at the typical rate, short-term ARIs are above 1, indicating no exceedance of the USEPA's level of concern and that adverse health effects are not expected. Under scenarios involving applications of 2,4-D at the maximum rate, short-term ARIs are below 1, indicating an exceedance of the USEPA's level of concern for human health for the following scenarios:

- Berry Picker (Child) - Airplane applications (forested).
- Native American (Child) - Airplane applications (forested).

Table 5-16 presents the summary risk results for accidental exposure scenarios involving application of 2,4-D at the maximum rate. ARIs are below 1 for 34 of the 59 scenarios evaluated; therefore, the accidental scenario was also evaluated under the typical application rate scenario. Table 5-17 presents the summary risk results for accidental exposure scenarios involving application of 2,4-D at the typical rate. ARIs are below 1 for 32 scenarios, indicating an exceedance of the USEPA's level of concern for human health. Exceedances under both the maximum application rate and typical application rate scenarios are listed below:

- Angler - Direct spray and ingestion of drinking water from a pond receiving a truck or helicopter spill.
- Berry Picker (Adult) - Direct spray, ingestion of drinking water from a pond receiving a truck or helicopter spill, and ingestion of directly sprayed berries.

- Berry Picker (Child) - Direct spray, contact with directly sprayed vegetation, ingestion of drinking water from a pond receiving a truck or helicopter spill, and ingestion of directly sprayed berries. For applications at the typical rate, the ARI is above 1 for the foliage exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Hiker/Hunter - Direct spray and ingestion of drinking water from a pond receiving a truck or helicopter spill.

- Native American (Adult) - Direct spray, ingestion of drinking water from a pond receiving a truck or helicopter spill, ingestion of fish from a pond receiving a truck or helicopter spill, and ingestion of directly sprayed berries.

- Native American (Child) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a truck or helicopter spill, ingestion of fish from a pond receiving a truck or helicopter spill, and ingestion of directly sprayed berries. For applications at the typical rate, the ARI is above 1 for the foliage exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Residential (Adult) - Direct spray and contact with directly sprayed lawn.

- Residential (Child) - Direct spray and contact with directly sprayed lawn.

- Swimmer (Child) - Swimming in a pond receiving a truck or helicopter spill.

Terrestrial - Woody Species

Table 5-18 presents the short-term summary risk results for routine public exposure scenarios involving use of 2,4-D to treat woody species in terrestrial environments. For short-term exposures involving applications at the typical rate, ARIs are below 1, indicating an exceedance of the USEPA's level of concern for human health, for the following scenarios:

- Berry Picker (Child) - Airplane applications (forested).

- Native American (Child) - Airplane applications (forested).

For applications at the maximum rate, short-term ARIs are below 1, indicating an exceedance of the USEPA's level of concern and a potential concern for human health, for the following scenarios:

- Berry Picker (Child) - Airplane applications (non-forested, forested), helicopter applications (non-forested), and high boom applications.

- Berry Picker (Adult) – Airplane applications (forested).

- Residential (Child) - Airplane applications (forested).

- Native American (Child) - Airplane applications (non-forested, forested) and helicopter applications (non-forested).

- Native American (Adult) – Airplane applications (forested).

Table 5-19 presents the summary risk results for accidental exposure scenarios involving application of 2,4-D at the maximum rate. ARIs are below 1 for 39 of the 59 scenarios evaluated; therefore, the accidental scenario was also evaluated under the typical application rate scenario. Table 5-20 presents the summary risk results for accidental exposure scenarios involving application of 2,4-D at the typical rate. ARIs are below 1 for 34 scenarios, indicating an exceedance of the USEPA's level of concern for human health. Exceedances under both the maximum application rate and typical application rate scenarios are listed below:

- Angler - Direct spray, ingestion of drinking water from a pond receiving a truck or helicopter spill, and ingestion of fish from a pond receiving a helicopter spill. For applications at the typical rate, the ARI is above 1 for the fish ingestion exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Berry Picker (Adult) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a truck or helicopter spill, and ingestion of directly sprayed berries. For applications at the typical rate, the ARI is above 1 for the foliage exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Berry Picker (Child) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a direct spray or truck or helicopter spill, and ingestion of directly sprayed berries. For applications at the typical rate, the ARI is above 1 for the drinking water spray exposure pathway indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Hiker/Hunter - Direct spray and ingestion of drinking water from a pond receiving a truck or helicopter spill.

- Native American (Adult) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a truck or helicopter spill, ingestion of fish from a pond receiving a truck or helicopter spill, and ingestion of directly sprayed berries. For applications at the typical rate, the ARI is above 1 for the foliage exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Native American (Child) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a truck or helicopter spill, ingestion of fish from a pond receiving a truck or helicopter spill, and ingestion of directly sprayed berries.

- Residential (Adult) - Direct spray and contact with directly sprayed lawn.

- Residential (Child) - Direct spray and contact with directly sprayed lawn.

- Swimmer (Adult) - Swimming in a pond receiving a helicopter spill. For applications at the typical rate, the ARI is above 1 for the swimming exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Swimmer (Child) - Swimming in a pond receiving a truck or helicopter spill.

Aquatic - Treatment of Floating and Emerged Vegetation

Table 5-21 presents the short-term summary risk results for routine public exposure scenarios involving use of 2,4-D to treat floating and emerged vegetation in aquatic environments. Note that spray drift onto a pond was modeled using the "non-forested" land type in AGDRIFT®. Short-term ARIs are greater than 1 under both the typical and the maximum application rate scenarios, indicating no exceedance of the USEPA's level of concern and that adverse health effects are not expected under the scenarios evaluated.

Table 5-22 presents the summary risk results for accidental exposure scenarios involving aquatic application of 2,4-D at the maximum application. ARIs are below 1 for 39 of 59 scenarios evaluated; therefore, the accidental scenario was also evaluated under the typical application rate scenario. Table 5-23 presents summary risk results for accidental exposure scenarios involving application of 2,4-D at the typical rate. ARIs are below 1 for 34 of 59 scenarios evaluated, indicating an exceedance of the USEPA's level of concern for human health. Exceedances under both the maximum application rate and typical application rate scenarios are listed below:

- Angler - Direct spray, ingestion of drinking water from a pond receiving a truck or helicopter spill, and ingestion of fish from a pond receiving a helicopter spill. For applications at the typical rate, the ARI is above 1 for the fish ingestion exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Berry Picker (Adult) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a truck or helicopter spill, and ingestion of directly sprayed berries. For applications at the typical rate, the ARI is above 1 for the foliage pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Berry Picker (Child) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a direct spray or truck or helicopter spill, and ingestion of directly sprayed berries. For applications at the typical rate, the ARI is above 1 for the drinking water from a pond receiving a direct spray exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Hiker/Hunter- Direct spray and ingestion of drinking water from a pond receiving a truck or helicopter spill.

- Native American (Adult) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a truck or helicopter spill, ingestion of fish from a pond receiving a truck or helicopter spill, and ingestion of directly sprayed berries. For applications at the typical rate, the ARI is above 1 for the foliage exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Native American (Child) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a truck or helicopter spill, ingestion of fish from a pond receiving a truck or helicopter spill, and ingestion of directly sprayed berries.

- Residential (Adult) - Direct spray and contact with directly sprayed lawn.

- Residential (Child) - Direct spray and contact with directly sprayed lawn.

- Swimmer (Adult) - Swimming in a pond receiving a helicopter spill. For applications at the typical rate, the ARI is above 1 for the swimming exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Swimmer (Child) - Swimming in a pond receiving a truck or helicopter spill.

Aquatic - Treatment of Submerged Vegetation (Volume of Water)

Table 5-24 presents the short-term summary risk results for routine public exposure scenarios involving use of 2,4-D used to treat submerged vegetation in a volume of water (aquatic environments). Note that spray drift onto a pond was modeled using the "non-forested" land type in AGDRIFT®. For applications at the typical rate, short-term ARIs are below 1, indicating an exceedance of the USEPA's level of concern for human health, for the following scenarios:

- Berry Picker (Child) - Airplane and helicopter applications.

- Residential (Child) - Airplane and helicopter applications.

- Native American (Child) - Airplane and helicopter applications.

For applications at the maximum application rate, short-term ARIs are below 1, indicating an exceedance of the USEPA's level of concern for human health, for the following scenarios:

- Berry Picker (Child) - Airplane and helicopter applications.

- Berry Picker (Adult) - Airplane applications.
- Residential (Child) - Airplane and helicopter applications.
- Residential (Adult) - Airplane applications.
- Native American (Child) - Airplane and helicopter applications.
- Native American (Adult) - Airplane applications.

Table 5-25 presents the summary risk results for accidental exposure scenarios involving applications at the maximum rate. ARIs are below 1 for 51 of 59 scenarios evaluated; therefore, the accidental scenario was also evaluated under the typical application rate scenario. Table 5-26 presents summary risk results for accidental exposure scenarios involving treatment of submerged vegetation at the typical application rate. ARIs are below 1 for 45 scenarios, indicating an exceedance of the USEPA's level of concern for human health. Exceedances under both the maximum application rate and typical application rate scenarios are listed below:

- Angler - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a direct spray or truck or helicopter spill, and ingestion of fish from a pond receiving a truck or helicopter spill. For applications at the typical rate, the ARI is above 1 for the fish ingestion from a pond receiving a truck spill exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.
- Berry Picker (Adult) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a direct spray or a truck or helicopter spill, and ingestion of directly sprayed berries.
- Berry Picker (Child) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a direct spray or truck or helicopter spill, and ingestion of directly sprayed berries.
- Hiker/Hunter - Direct spray, contact with directly sprayed foliage, and ingestion of drinking water from a pond receiving a direct spray or truck or helicopter spill.
- Native American (Adult) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a direct spray or truck or helicopter spill, ingestion of fish from a pond receiving a direct spray or truck or helicopter spill, and ingestion of directly sprayed berries. For applications at the typical rate, the ARI is above 1 for the water and fish ingestion from a pond receiving a direct spray exposure pathways, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.
- Native American (Child) - Direct spray, contact with directly sprayed foliage, ingestion of drinking water from a pond receiving a direct spray or truck or helicopter spill, ingestion of fish from a pond receiving a direct spray truck or helicopter spill, and ingestion of directly sprayed berries. For applications at the typical rate, the ARI is above 1 for the fish ingestion from a pond receiving a direct spray exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.
- Residential (Adult) - Direct spray and contact with directly sprayed lawn.
- Residential (Child) - Direct spray and contact with directly sprayed lawn.
- Swimmer (Adult) - Swimming in a pond receiving a truck or helicopter spill. For applications at the typical rate, the ARI is above 1 for the truck exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

- Swimmer (Child) - Swimming in a pond receiving a direct spray or truck or helicopter spill. For applications at the typical rate, the ARI is above 1 for the direct spray exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

Aquatic - Treatment of Submerged Vegetation (Pond Bottom)

As discussed previously, there is no spray drift associated with application of granular formulations of 2,4-D for pond bottom treatments. Therefore, routine exposures are not expected for public receptors. Accidental exposures could occur if public receptors enter or use ponds treated with this formulation of 2,4-D right after application, even though signs would be posted (a re-entry scenario).

Table 5-27 presents the summary risk results for accidental exposure scenarios involving applications at the maximum rate. ARIs are below 1 for 9 of the 13 scenarios evaluated; therefore, the accidental scenario was also evaluated under the typical application rate scenario. Table 5-28 presents summary risk results for accidental exposure scenarios at the typical rate. ARIs are below 1 for six of the scenarios, indicating an exceedance of the USEPA's level of concern for human health. Exceedances under both the maximum application rate and typical application rate scenarios are listed below:

- Angler - Ingestion of drinking water from a treated pond (re-entry).
- Berry Picker (Adult) - Ingestion of drinking water from a treated pond (re-entry).
- Berry Picker (Child) - Ingestion of drinking water from a treated pond (re-entry).
- Hiker/Hunter - Ingestion of drinking water from a treated pond (re-entry).
- Native American (Adult) - Ingestion of drinking water and fish from a treated pond (re-entry). For applications at the typical rate, the ARI is above 1 for the fish ingestion exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.
- Native American (Child) - Ingestion of drinking water and fish from a treated pond (re-entry). For applications at the typical rate, the ARI is above 1 for the fish ingestion exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.
- Swimmer (Child) - Swimming in a treated pond (re-entry). For applications at the typical rate, the ARI is above 1 for this exposure pathway, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected.

5.3.2.4 Fluroxypyr

Fluroxypyr is proposed for use on rangeland, public-domain forestland, energy and mineral sites, rights-of-way, and recreational and cultural sites. Fluroxypyr may be applied using the following vehicles and methods: airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications). All public receptors are assumed to be potentially exposed to fluroxypyr spray drift resulting from aerial applications from airplanes or helicopters and boom/broadcast (both low-boom and high-boom) application methods from trucks or ATVs/UTVs. As noted above, spot applications are small and focused, and very little if any spray drift is generated; therefore, public receptors are not assumed to be impacted by herbicide active ingredient spray from spot applications.

The routine-use scenarios assume that public receptors are exposed to spray drift via dermal contact, incidental ingestion, and dietary exposure pathways. Both the typical and maximum application rates are considered (see Table 4-1). The ARIs combine all the exposure estimates to derive a cumulative effect ARI. The short-term routine-use scenario ARIs for fluroxypyr are presented in Table 5-29. As discussed previously, no dermal NOAELs are available, there are no concerns for developmental or neurological toxicity, and the USEPA has not derived an acute PAD (USEPA 2007). Therefore, short-term ARIs are based on incidental oral exposure (and therefore are calculated only for swimming pathways). Short-term routine-use scenario ARIs for fluroxypyr are greater than 1 under the typical and maximum application rate scenarios for all public receptors, indicating no exceedance of the USEPA's level of concern under the scenarios evaluated.

The accidental scenario assumes that public receptors are exposed directly to maximum herbicide active ingredient application rates (as shown on Table 4-1) via dermal contact (direct spray of receptor, contact with directly sprayed vegetation, and contact with directly sprayed water), incidental ingestion of water while swimming, or dietary exposure pathways (drinking water, berry ingestion, and fish ingestion). The accidental scenario for a pond assumes that receptors swim in or obtain drinking water from a pond that has been directly sprayed with a herbicide active ingredient or that has received a spill (from a truck or helicopter). Cumulative accidental ARIs were not calculated, as it is assumed that each receptor would be accidentally exposed via only one potential exposure pathway. The accidental scenario ARIs are presented in Table 5-30. Because acute dietary and dermal toxicity values are not available, accidental scenario ARIs for fluroxypyr were calculated only for incidental oral pathways (swimming). The ARIs for the swimming pathways are greater than 1, indicating no exceedance of the USEPA's level of concern under the scenarios evaluated.

In summary, these results show that fluroxypyr risks are not expected to exceed the USEPA's level of concern for any of the public receptors under the scenarios evaluated and that no adverse health effects are expected.

5.3.2.5 Rimsulfuron

Rimsulfuron is proposed for use on rangeland, public-domain forestland, energy and mineral sites, rights-of-way, and recreational and cultural sites. Note that for rangeland and public-domain forest land, the typical application rate is 0.0469 lb a.i./acre and the maximum application rate is 0.0625 lb a.i./acre. For energy and minerals sites, recreation and cultural sites, and rights-of-way, the typical and maximum application rates are the same (0.0625 lb a.i./acre). Therefore, the typical application rate scenario is applicable to rangeland and public-domain forest land, and the maximum application rate scenario is applicable to all five land programs. Rimsulfuron may be applied using the following vehicles and methods: airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications). All public receptors are assumed to be potentially exposed to rimsulfuron spray drift resulting from aerial applications from airplanes or helicopters and boom/broadcast (both low-boom and high-boom) application methods from trucks or ATVs/UTVs. As noted above, spot applications are small and focused, and very little if any spray drift is generated; therefore, public receptors are not assumed to be impacted by herbicide active ingredient spray from spot applications.

The routine-use scenarios assume that public receptors are exposed to spray drift via dermal contact, incidental ingestion, and dietary exposure pathways. Both the typical and maximum application rates are considered (see Table 4-1). The ARIs combine all the exposure estimates to derive a cumulative effect ARI. As discussed previously the USEPA has not derived an acute PAD for rimsulfuron (USEPA 2009a). Therefore, short-term ARIs do not include dietary exposure pathways. Intermediate-/long-term ARIs including dietary pathways using the chronic PAD developed by the USEPA (2009a) were calculated in the uncertainty analysis and are presented in Section 5.5.4.1. The short-term routine-use scenario ARIs for rimsulfuron are presented in Table 5-31. Short-term routine-use scenario ARIs for rimsulfuron are greater than 1 under the typical and maximum application rate scenarios for all public receptors, indicating no exceedance of the USEPA's level of concern under the scenarios evaluated.

The accidental scenario assumes that public receptors are exposed directly to maximum herbicide active ingredient application rates (as shown on Table 4-1) via dermal contact (direct spray of receptor, contact with directly sprayed vegetation, and contact with directly sprayed water), incidental ingestion of water while swimming, or dietary exposure pathways (drinking water, berry ingestion, and fish ingestion). The accidental scenario for a pond assumes that receptors swim in or obtain drinking water from a pond that has been directly sprayed with a herbicide active ingredient or that has received a spill (from a truck or helicopter). Cumulative accidental ARIs were not calculated, as it is assumed that each receptor would be accidentally exposed via only one potential exposure pathway. The accidental scenario ARIs are presented in Table 5-32. Because acute dietary toxicity values are not available, accidental scenario ARIs for rimsulfuron do not include dietary exposures. ARIs are greater than 1, indicating no exceedance of the USEPA's level of concern under the scenarios evaluated.

In summary, these results show that rimsulfuron risks are not expected to exceed the USEPA's level of concern for any of the public receptors under the scenarios evaluated and that no adverse health effects are expected.

5.4 Uncertainty Analysis

Uncertainty is introduced in several places throughout the risk assessment process, every time an assumption is made. In accordance with USEPA guidance (USEPA 1989), the uncertainty associated with each step of the risk characterization process is discussed in this section of the report.

Within each of the four steps of the human health risk evaluation process, assumptions must be made, given the lack of absolute scientific knowledge. Some of the assumptions are supported by considerable scientific evidence, while others have less support. Every assumption introduces some degree of uncertainty into the risk evaluation process. Regulatory risk evaluation methodology requires that conservative assumptions be made throughout the risk evaluation to ensure that public health is protected. Therefore, when all of the assumptions are combined, it is much more likely that risks are overestimated rather than underestimated.

5.4.1 Hazard Identification

The Hazard Identification step involves identifying the herbicide active ingredients to be evaluated quantitatively in the HHRA and providing toxicity information for these active ingredients. Toxicity information for the five herbicide active ingredients evaluated in this HHRA was collected mainly from USEPA reports presenting compiled results of toxicity studies conducted by the manufacturers and other entities. For the most part, the USEPA had sufficient information to place the herbicide active ingredients in the appropriate acute toxicity categories, and to determine their carcinogenic potential. Appropriate studies were available to determine subchronic, chronic, developmental, and reproductive toxicity. While there is always uncertainty in extrapolating animal information to humans, sufficient information was available to make a determination about toxicity for all the herbicide active ingredients.

5.4.2 Dose-response Assessment

The purpose of the dose-response assessment is to define the relationship between the dose of a chemical and the likelihood or magnitude of an adverse effect (response). Risk assessment methodologies typically divide potential health effects of concern into two general categories: effects with a threshold (noncarcinogenic) and effects assumed to be without a threshold (potentially carcinogenic). None of the five herbicide active ingredients evaluated in this HHRA are designated as potential carcinogens by the USEPA; therefore, noncancer dose-response values were used in the evaluation. There are several sources of uncertainty in the development of dose-response values.

5.4.2.1 Animal-to-human Extrapolation

For many chemicals, animal studies provide the only reliable information with which to estimate adverse human health effects. Extrapolation from animals to humans introduces uncertainty into the risk characterization. Usually, the difference between the human reaction to a chemical and the test animal reaction to a chemical is unknown. If a chemical's fate and the mechanisms by which it causes adverse effects are known in both animals and humans, uncertainty is reduced. When the fate and mechanism for the chemical are unknown, uncertainty increases.

Conservative assumptions that incorporate uncertainty factors are used to extrapolate from animals to humans such that it is more likely that effects in humans are overestimated than underestimated. When data are available from several species, the highest dose that that does not cause effects in the most sensitive species is used to determine the NOAEL, which is used to calculate the RfD and the PAD. The PAD is calculated by dividing the NOAEL by uncertainty factors, generally of 1 to 10 each, to account for intraspecies variability, interspecies variability, and study duration. When using the NOAEL to calculate MOEs, the target MOE is typically 100 to account for intraspecies and interspecies variability. Generally, additional uncertainty factors for study duration are not required, because separate NOAELs are used for short-, intermediate-, and long-term exposures.

The use of the uncertainty factors compensates for uncertainties involved in extrapolating from animals to humans. Nevertheless, because the fate of a chemical can differ in animals and humans, it is possible that animal experiments will not reveal an adverse effect that would manifest itself in humans. This can result in an underestimation of the effects in humans. The opposite may also be true: effects observed in animals may not be observed in humans, resulting in an overestimation of potential adverse human health effects.

5.4.2.2 Availability of NOAELs

NOAELs are not available for all of the exposure durations and routes for all of the herbicide active ingredients. In most cases, the USEPA has not developed specific NOAELs because the herbicide active ingredient is not considered toxic through a specific exposure route. For example, there are no dermal NOAELs for aminopyralid because a dermal toxicity study did not show any effects at the limit dose of 1,000 mg/kg-day (USEPA 2009a). Therefore, risk calculations were not conducted for certain herbicide active ingredients and certain exposure routes. It is likely that risks are not being underestimated because the specific exposure route is unlikely to show toxicity.

5.4.3 Exposure Assessment

There are uncertainties involved in the development of exposure scenarios and in the estimation of herbicide active ingredient doses to which humans could be exposed.

5.4.3.1 Exposure Scenarios

Exposure scenarios in a risk evaluation are selected to be representative of current and reasonably foreseeable site use. In accordance with pesticide risk assessment approaches, both occupational and public (non-worker) receptors were evaluated. The selection of occupational receptors considered the BLM's specific land programs, application types, application vehicles, and application methods. The occupational receptors include pilots, applicators, mixer/loaders, and combined applicator/mixer/loaders. Most occupational receptors are likely to have little herbicide active ingredient exposure because of the use of personal protective equipment and other health and safety precautions. The accidental spill scenario evaluated for the occupational receptor is also very unlikely, since a worker would take necessary precautions to prevent spills.

The HHRA evaluated a wide range of potential public receptors, including hiker/hunters, berry pickers, anglers, swimmers, nearby residents, and Native Americans. Although there are many different exposure scenarios and receptors that could be evaluated, these receptors cover a range of potential exposures that could occur under worst-case conditions on BLM-administered lands. It is assumed that these receptors could be exposed via up to six exposure pathways including herbicide spray, contact with sprayed foliage, ingestion of sprayed water as drinking water or occasional ingestion while swimming, dermal contact with sprayed water, ingestion of sprayed berries, and ingestion of fish that have bioaccumulated a herbicide active ingredient from sprayed water. Under the routine scenarios, receptors are assumed to be exposed to spray drift, while under the accidental scenarios, receptors are assumed to be exposed to direct spray. The Native American receptor is assumed to be exposed through all of these exposure pathways, which is likely to be a conservative assumption.

While it is possible that public receptors use public lands under intermediate- and long-term time frames, it is unlikely that public receptors would be exposed to herbicides under the routine-use scenario for more than a short-term exposure, which is defined as up to 30 days (USEPA 2012a). Therefore, a short-term scenario was evaluated in this HHRA. Although it is highly unlikely that public receptors would be potentially exposed to herbicides for longer than a short-term time frame, both an intermediate- and a long-term exposure scenario are evaluated in this Uncertainty Analysis. Appendix E presents the calculation of ARIs for the intermediate- and long-term exposure scenarios for the public receptors. The results of this analysis are discussed in Section 5.4.4.1.

5.4.3.2 Estimation of Dose

Various conservative assumptions were made to estimate the herbicide active ingredient doses to which occupational and public receptors could be exposed. For the occupational receptors, exposure doses were estimated using unit exposure information from the *Occupational Pesticide Handler Unit Exposure Surrogate Reference Guide* (USEPA 2012b) which contains dermal and inhalation exposure data for workers mixing, loading, or applying pesticides. The USEPA has developed a series of standard UE values for various exposure scenarios, which were used in this HHRA. For the occupational worker accidental spill scenario, it was assumed that the herbicide active ingredient could spill directly onto the worker and be absorbed through the skin. These exposure pathways are likely to result in conservative risk estimates.

For the public receptors, various conservative assumptions were used to estimate exposures. These exposure assumptions were generally derived from USEPA databases, such as the EFH (USEPA 2011a). The exposure assumptions listed in these guidance documents are generally conservative and are not site-specific, and are meant to account for a wide range of exposure situations. To estimate exposures to the public from off-site deposition of herbicide active ingredients, the computer model AgDRIFT® was used (SDTF 2002). The AgDRIFT® Tier I and Tier II evaluations were used in this HHRA because they allow the development of routine generic application scenarios that are more representative of the range of applications likely employed by the BLM. The terrestrial deposition rates and water concentrations calculated by AgDRIFT® are likely to be upper-end estimates. The computer model GLEAMS was used to estimate runoff of the terrestrial herbicide active ingredients into ponds. For the three terrestrial herbicide active ingredients, pond concentrations calculated in AgDRIFT® were added to the highest pond concentrations calculated in GLEAMS. This likely overestimates the true pond concentrations because AgDRIFT® concentrations represent relatively short duration concentrations. It is unlikely that a receptor would be exposed to pond water on the day that both drift concentrations and runoff concentrations are present.

Worst-case assumptions that are unlikely to occur were made to evaluate the accidental spray and spill scenarios. The accidental spray scenario assumed that the receptor was exposed to direct spray at the maximum herbicide active ingredient application rate. The spill scenario assumed that a fully-loaded truck or helicopter emptied its contents into a pond while transporting the herbicide to the application site. In reality, the BLM requires that the herbicide be mixed at the application site; therefore, it is unlikely that premixed herbicide would be transported from one location to another.

5.4.4 Risk Characterization

The potential risk of adverse human health effects is characterized based on estimated potential exposures and potential dose-response relationships. Generally, the goal of a risk evaluation is to estimate a reasonable upper-bound to potential exposure and risk. Most of the assumptions about exposure and toxicity used in this evaluation are representative of statistical upper-bounds or even maxima for each parameter. The result of combining several such upper-bound assumptions is that the final estimate of potential exposure or potential risk is extremely conservative.

The health risks estimated in the risk characterization generally apply to the receptors whose activities and locations were described in the exposure assessment. Some people will always be more sensitive than the average person and, therefore, will be at greater risk. Dose-response values used to calculate risk, however, are frequently derived to account for additional sensitivity of subpopulations (e.g., an uncertainty factor of 10 is used to account for intraspecies differences). Therefore, it is unlikely that this source of uncertainty contributes significantly to the overall uncertainty of the risk assessment.

The large number of assumptions made in the risk characterization introduces uncertainty in the results. Any one person’s potential exposure and subsequent risk are influenced by all the parameters mentioned above and will vary on a case-by-case basis. Despite inevitable uncertainties associated with the steps used to derive potential risks, the use of numerous conservative (health-protective) assumptions will most likely lead to a large overestimate of potential risks from the site.

5.4.4.1 Public Receptors – Intermediate- and Long-term Exposure Scenario

As stated previously, it is highly unlikely that public receptors would be exposed to herbicides for more than a short-term exposure period. Nonetheless, both an intermediate- and a long-term exposure scenario are evaluated in this Uncertainty Analysis. While these exposures are extremely unlikely, they were included in the uncertainty analysis for completeness.

Dose response values for intermediate- and long-term exposures are presented in Table 3-1. The exposure assumptions listed in Table 4-5 were used to evaluate the intermediate- and long-term exposure scenarios. EPCs for routine-use intermediate- and long-term exposures were developed in Section 4.4.2. The deposition rates and the EPCs used to evaluate the routine-use intermediate- and long-term exposure scenarios are presented in Tables 4-8 to 4-12. Appendix E presents risk calculation spreadsheets and summary ARI tables for public receptors under intermediate- and long-term exposure scenarios.

As indicated in Appendix E, routine-use scenario ARIs for intermediate- and long-term exposure scenarios are greater than 1 under both typical and maximum application rate scenarios for all public receptors for aminopyralid, clopyralid, fluroxypyr, and rimsulfuron, indicating no exceedance of the USEPA's level of concern and that no adverse health effects are expected. ARIs are below 1, indicating an exceedance of the USEPA's level of concern for human health for many of the receptors and scenarios for the various formulations of 2,4-D under the typical application rate scenario and for the majority of scenarios under the maximum application rate scenario. There were no exceedances for the swimmer (adult or child) receptor under any scenario. Table 5-33 presents a listing of the various routine-use scenarios with ARIs less than 1 for short-, intermediate-, and long-term exposures. As stated previously, intermediate- and long-term exposures for public receptors are unlikely.

5.4.4.2 Biomonitoring Study – 2,4-D

The Farm Family Exposure Study evaluated exposure of 34 farm families in Minnesota and South Carolina to 2,4-D following a single application as part of the regular farm practice by each family (Alexander et al. 2007). The single applications conducted by each family were mostly conducted using boom sprayers, with some use of hand held wands during a portion of the application. The formulations used included aqueous solutions or emulsifiable concentrates; 21 of the applications were 2,4-D amine and 13 were ester formulations. Acres treated ranged from 10 to 281.

Applicators, spouses, and children (age 4 to 17) collected all urine for 5 days—the day prior to the application, the day of the application, and for 3 days following the application. All 34 applicators in the study were male, and all 34 spouses were female. A total of 53 children (31 male and 22 female) participated in the study. Systemic dose was estimated based on the urine concentrations. Geometric mean and maximum doses are presented below. Due to differences in exposure estimates, children were further subdivided by the authors into age groups 4 to 11 (33 children) and 12 to 17 (20 children).

The strongest predictors of potential exposures in the study were:

- Applicator use of gloves during mixing and application of the herbicide, which reduced exposure greatly;
- Number of acres treated, which increased exposure; and
- Repairing equipment, which increased exposure.

Receptor	Geometric Mean Short-term Dose (mg/kg-day)	Maximum Short-term Dose (mg/kg-day)
Applicator (male)	0.00246	0.05848
Spouse (female)	0.00008	0.00114
Children (age 4-11)	0.00032	0.00716
Children (12-17)	0.00012	0.03107

Data from Alexander et al. 2007, Table 3. Units converted from ug/kg-day to mg/kg-day.

As described in Section 3.2.3.2, the USEPA selected a NOAEL of 25 mg/kg-day for short-term (up to 30 days) non-dietary exposures to 2,4-D (USEPA 2005 a, b). To compare the doses above to the USEPA NOAEL, MOEs have been calculated (see Section 5.1.2). MOEs have been calculated for short-term exposure based on both the geometric mean and maximum doses, as presented below:

Receptor	Short-Term MOE	
	Geometric Mean	**Maximum**
Applicator (male)	10,163	427
Spouse (female)	312,500	21,930
Children (age 4-11)	78,125	3,492
Children (age 12-17)	208,333	805

Short-Term MOE = Short-term NOAEL (25 mg/kg-day) divided by dose (mg/kg-day). MOE is calculated based on both the median and the maximum dose.

As discussed in Section 5.1.2, target MOEs are derived by the USEPA to account for the uncertainties associated with the NOAEL. Calculated MOEs above the target MOE do not exceed the USEPA's level of concern and indicate that adverse health effects are not expected. Calculated MOE values less than the target MOE indicate a potential concern for human health concerns. The USEPA selected a target MOE of 1,000 for residential exposures and 100 for occupational exposures to 2,4-D (USEPA 2005a,b).

MOEs based on the geometric mean and maximum dose for younger children and spouses are greater than 1,000, indicating no exceedance of the USEPA's level of concern for residential exposure. The adult applicator is an occupational receptor and therefore, an MOE of 100 is appropriate. MOEs for adult applicators are greater than 100, indicating no exceedance of the USEPA's level of concern for occupational exposure. The older child MOE based on the geometric mean dose is greater than 1,000, indicating no exceedance of the USEPA's level of concern for residential exposure. The older child MOE based on the maximum dose is slightly below 1,000. Note that the maximum dose greatly exceeds the geometric mean dose as well as the 90^{th} percentile (0.001 mg/kg-day). Based on the 90^{th} percentile, the MOE is 25,000, indicating that 90% of the exposures are below the level of concern and evaluating the maximum is conservative.

The results of the Farm Family Exposure Study (Alexander et al. 2007) are consistent with the HHRA results for 2,4-D presented in Section 5.3.2.3, in that at higher exposure levels the USEPA's level of concern may be exceeded.

Table 5-1
Toxicity Values used in ARI Calculations

Scenario	Pathway	Toxicity Value for ARI		
		Short - Term	**Intermediate - Term**	**Long - Term**
Occupational	Inhalation	Short - Term Inhalation NOAEL	Intermediate - Term Inhalation NOAEL	Long - Term Inhalation NOAEL
Occupational/Public	Dermal	Short - Term Dermal NOAEL	Intermediate - Term Dermal NOAEL	Long - Term Dermal NOAEL
Public	Oral (incidental ingestion and dermal for the swimming pathway)	Short- Term Oral NOAEL	Not Applicable Evaluated in the uncertainty analysis using the Intermediate - Term Oral NOAEL	Not Applicable Evaluated in the uncertainty analysis using the Intermediate - Term Oral NOAEL (Long - Term Oral NOAELs not available)
Public	Dietary	Acute PAD	Not Applicable Evaluated in the uncertainty analysis using the Chronic PAD	Not Applicable Evaluated in the uncertainty analysis using the Chronic PAD

ARI - Aggregate Risk Index.
NOAEL - No Observable Adverse Effect Level.
PAD - Population Adjusted Dose.

Table 5-2
Aggregate Risk Indices - Occupational Scenarios
Herbicide: Aminopyralid
Programs: Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites

Application Type	Application Vehicle	Application Method	Receptor	Short-Term	Intermediate-Term	Long-Term	Short-Term	Intermediate-Term	Long-Term	Concentrated Solution (a)
Aerial	Plane	Fixed Wing	Pilot	15,588	15,588	NC	3,684	3,684	NC	NC
Aerial	Plane	Fixed Wing	Mixer/Loader	3,643	3,643	NC	861	861	NC	NC
Aerial	Helicopter	Rotary	Pilot	38,971	38,971	NC	9,211	9,211	NC	NC
Aerial	Helicopter	Rotary	Mixer/Loader	9,107	9,107	NC	2,152	2,152	NC	NC
Ground	Human	Backpack	Applicator/Mixer/Loader	684,755	684,755	NC	121,388	121,388	NC	NC
Ground	Human	Horseback	Applicator	#DIV/0!	#DIV/0!	NC	#DIV/0!	#DIV/0!	NC	NC
Ground	Human	Horseback	Mixer/Loader	#DIV/0!	#DIV/0!	NC	#DIV/0!	#DIV/0!	NC	NC
Ground	Human	Horseback	Applicator/Mixer/Loader	91,301	91,301	NC	36,416	36,416	NC	NC
Ground	ATV/UTV	Spot	Applicator	217,436	217,436	NC	42,828	42,828	NC	NC
Ground	ATV/UTV	Spot	Mixer/Loader	4,856,816	4,856,816	NC	860,981	860,981	NC	NC
Ground	ATV/UTV	Spot	Applicator/Mixer/Loader	202,338	202,338	NC	39,855	39,855	NC	NC
Ground	ATV/UTV	Boom/Broadcast	Applicator	779,412	779,412	NC	153,520	153,520	NC	NC
Ground	ATV/UTV	Boom/Broadcast	Mixer/Loader	1,517,755	1,517,755	NC	322,868	322,868	NC	NC
Ground	ATV/UTV	Boom/Broadcast	Applicator/Mixer/Loader	419,968	419,968	NC	82,721	82,721	NC	NC
Ground	Truck Mount	Spot	Applicator	119,208	119,208	NC	19,273	19,273	NC	NC
Ground	Truck Mount	Spot	Mixer/Loader	2,396,455	2,396,455	NC	322,868	322,868	NC	NC
Ground	Truck Mount	Spot	Applicator/Mixer/Loader	110,931	110,931	NC	17,935	17,935	NC	NC
Ground	Truck Mount	Boom/Broadcast	Applicator	415,686	415,686	NC	122,816	122,816	NC	NC
Ground	Truck Mount	Boom/Broadcast	Mixer/Loader	809,469	809,469	NC	191,329	191,329	NC	NC
Ground	Truck Mount	Boom/Broadcast	Applicator/Mixer/Loader	223,983	223,983	NC	66,177	66,177	NC	NC

ARI - Aggregate Risk Index. ARI is based on inhalation exposure because based on the toxicity assessment, dermal exposure is not of concern. Values less than one represent a level of concern.
ATV - All-Terrain Vehicle.
UTV - Utility Vehicle.

NC - Not calculated. Based on toxicity assessment, dermal exposure is not of concern, and long-term inhalation is not a concern for seasonal treatment.
(a) - Based on the assumption that a spill of concentrated liquid occurs to worker skin.

Table 5-3
Aggregate Risk Indices - Occupational Scenarios
Herbicide: Clopyralid
Programs: Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites

				Typical Application Rate Scenario ARIs			Maximum Application Rate Scenario ARIs			Accidental Scenario ARIs (Short-Term Dermal)
Application Type	Application Vehicle	Application Method	Receptor	Short-Term	Intermediate-Term	Long-Term	Short-Term	Intermediate-Term	Long-Term	Concentrated Solution (a)
Aerial	Plane	Fixed Wing	Pilot	3,507	701.5	NC	584.6	116.9	NC	NC
Aerial	Plane	Fixed Wing	Mixer/Loader	820	164	NC	137	27	NC	NC
Aerial	Helicopter	Rotary	Pilot	8,768	1,754	NC	1,461	292.3	NC	NC
Aerial	Helicopter	Rotary	Mixer/Loader	2,049	410	NC	341	68	NC	NC
Ground	Human	Backpack	Applicator/Mixer/Loader	154,070	30,814	NC	19,259	3,852	NC	NC
Ground	Human	Horseback	Applicator	#DIV/0!	#DIV/0!	NC	#DIV/0!	#DIV/0!	NC	NC
Ground	Human	Horseback	Mixer/Loader	#DIV/0!	#DIV/0!	NC	#DIV/0!	#DIV/0!	NC	NC
Ground	Human	Horseback	Applicator/Mixer/Loader	20,543	4,109	NC	5,778	1,156	NC	NC
Ground	ATV/UTV	Spot	Applicator	48,923	9,785	NC	6,795	1,359	NC	NC
Ground	ATV/UTV	Spot	Mixer/Loader	1,092,784	218,557	NC	136,598	27,320	NC	NC
Ground	ATV/UTV	Spot	Applicator/Mixer/Loader	45,526	9,105	NC	6,323	1,265	NC	NC
Ground	ATV/UTV	Boom/Broadcast	Applicator	175,368	35,074	NC	24,357	4,871	NC	NC
Ground	ATV/UTV	Boom/Broadcast	Mixer/Loader	341,495	68,299	NC	51,224	10,245	NC	NC
Ground	ATV/UTV	Boom/Broadcast	Applicator/Mixer/Loader	94,493	18,899	NC	13,124	2,625	NC	NC
Ground	Truck Mount	Spot	Applicator	26,822	5,364	NC	3,058	612	NC	NC
Ground	Truck Mount	Spot	Mixer/Loader	539,202	107,840	NC	51,224	10,245	NC	NC
Ground	Truck Mount	Spot	Applicator/Mixer/Loader	24,959	4,992	NC	2,845	569	NC	NC
Ground	Truck Mount	Boom/Broadcast	Applicator	93,529	18,706	NC	19,485	3,897	NC	NC
Ground	Truck Mount	Boom/Broadcast	Mixer/Loader	182,131	36,426	NC	30,355	6,071	NC	NC
Ground	Truck Mount	Boom/Broadcast	Applicator/Mixer/Loader	50,396	10,079	NC	10,499	2,100	NC	NC

ARI - Aggregate Risk Index. ARI is based on inhalation exposure because based on the toxicity assessment, dermal exposure is not of concern. Values less than one represent a level of concern.
ATV - All-Terrain Vehicle.
UTV - Utility Vehicle.
NC - Not calculated. Based on toxicity assessment, dermal exposure is not of concern, and long-term inhalation is not a concern for seasonal treatment.
(a) - Based on the assumption that a spill of concentrated liquid occurs to worker skin.

Table 5-4
Aggregate Risk Indices - Occupational Scenarios
Herbicide: 2,4-D (Land; Annual/Perennial Species; Liquid Formulation)
Programs: Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites

				Typical Application Rate Scenario ARIs			Maximum Application Rate Scenario ARIs			Accidental Scenario ARIs (Short-Term Dermal)		
Application Type	Application Vehicle	Application Method	Receptor	Short-Term	Intermediate-Term	Long-Term	Short-Term	Intermediate-Term	Long-Term	Concentrated Solution (a)	Mixed (Maximum) Solution (b)	Mixed (Typical) Solution (c)
Aerial	Plane	Fixed Wing	Pilot	35	21	7	6	3	1.2	**0.001**	**0.02**	**0.04**
Aerial	Plane	Fixed Wing	Mixer/Loader	5	3	**0.98**	**0.8**	**0.5**	**0.2**	**0.001**	**0.02**	**0.04**
Aerial	Helicopter	Rotary	Pilot	87	52	17	15	9	3	**0.001**	**0.02**	**0.04**
Aerial	Helicopter	Rotary	Mixer/Loader	12	7	2	2	1.2	**0.4**	**0.001**	**0.02**	**0.04**
Ground	Human	Backpack	Applicator/Mixer/Loader	40	24	8	5	3	**0.999**	**0.001**	**0.02**	**0.04**
Ground	Human	Horseback	Applicator	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**0.001**	**0.02**	**0.04**
Ground	Human	Horseback	Mixer/Loader	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**0.001**	**0.02**	**0.04**
Ground	Human	Horseback	Applicator/Mixer/Loader	5	3	1.1	1.5	**0.9**	**0.3**	**0.001**	**0.02**	**0.04**
Ground	ATV/UTV	Spot	Applicator	119	71	24	16	10	3	**0.001**	**0.02**	**0.04**
Ground	ATV/UTV	Spot	Mixer/Loader	6,542	3,925	1,308	818	491	164	**0.001**	**0.02**	**0.04**
Ground	ATV/UTV	Spot	Applicator/Mixer/Loader	115	69	23	16	10	3	**0.001**	**0.02**	**0.04**
Ground	ATV/UTV	Boom/Broadcast	Applicator	2,548	1,529	510	354	212	71	**0.001**	**0.02**	**0.04**
Ground	ATV/UTV	Boom/Broadcast	Mixer/Loader	2,044	1,227	409	307	184	61	**0.001**	**0.02**	**0.04**
Ground	ATV/UTV	Boom/Broadcast	Applicator/Mixer/Loader	828	497	166	115	69	23	**0.001**	**0.02**	**0.04**
Ground	Truck Mount	Spot	Applicator	65	39	13	7	4	1	**0.001**	**0.02**	**0.04**
Ground	Truck Mount	Spot	Mixer/Loader	3,228	1,937	646	307	184	61	**0.001**	**0.02**	**0.04**
Ground	Truck Mount	Spot	Applicator/Mixer/Loader	63	38	13	7	4	1	**0.001**	**0.02**	**0.04**
Ground	Truck Mount	Boom/Broadcast	Applicator	1,359	815	272	283	170	57	**0.001**	**0.02**	**0.04**
Ground	Truck Mount	Boom/Broadcast	Mixer/Loader	1,090	654	218	182	109	36	**0.001**	**0.02**	**0.04**
Ground	Truck Mount	Boom/Broadcast	Applicator/Mixer/Loader	442	265	88	92	55	18	**0.001**	**0.02**	**0.04**

ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
ATV - All-Terrain Vehicle.
UTV - Utility Vehicle.
(a) - Based on the assumption that a spill of concentrated liquid occurs to worker skin.
(b) - Based on the assumption that a spill to worker skin occurs after concentrated liquid is mixed with water to the maximum application rate.
(c) - Based on the assumption that a spill to worker skin occurs after concentrated liquid is mixed with water to the typical application rate.

Table 5-5
Aggregate Risk Indices - Occupational Scenarios
Herbicide: 2,4-D (Land; Woody Species; Liquid Formulation)
Programs: Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites

				Typical Application Rate Scenario ARIs			Maximum Application Rate Scenario ARIs			Accidental Scenario ARIs (Short-Term Dermal)		
Application Type	Application Vehicle	Application Method	Receptor	Short-Term	Intermediate-Term	Long-Term	Short-Term	Intermediate-Term	Long-Term	Concentrated Solution (a)	Mixed (Maximum) Solution (b)	Mixed (Typical) Solution (c)
Aerial	Plane	Fixed Wing	Pilot	17	10	3	3	2	**0.6**	**0.001**	**0.02**	**0.04**
Aerial	Plane	Fixed Wing	Mixer/Loader	2	1.5	**0.5**	**0.4**	**0.2**	**0.1**	**0.001**	**0.02**	**0.04**
Aerial	Helicopter	Rotary	Pilot	44	26	9	7	4	1.5	**0.001**	**0.02**	**0.04**
Aerial	Helicopter	Rotary	Mixer/Loader	6	4	1.2	1.02	**0.6**	**0.2**	**0.001**	**0.02**	**0.04**
Ground	Human	Backpack	Applicator/Mixer/Loader	20	12	4	2	1.5	**0.5**	**0.001**	**0.02**	**0.04**
Ground	Human	Horseback	Applicator	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**0.001**	**0.02**	**0.04**
Ground	Human	Horseback	Mixer/Loader	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**0.001**	**0.02**	**0.04**
Ground	Human	Horseback	Applicator/Mixer/Loader	3	2	**0.5**	**0.7**	**0.4**	**0.1**	**0.001**	**0.02**	**0.04**
Ground	ATV/UTV	Spot	Applicator	59	36	12	8	5	2	**0.001**	**0.02**	**0.04**
Ground	ATV/UTV	Spot	Mixer/Loader	3,271	1,962	654	409	245	82	**0.001**	**0.02**	**0.04**
Ground	ATV/UTV	Spot	Applicator/Mixer/Loader	58	35	12	8	5	2	**0.001**	**0.02**	**0.04**
Ground	ATV/UTV	Boom/Broadcast	Applicator	1,274	764	255	177	106	35	**0.001**	**0.02**	**0.04**
Ground	ATV/UTV	Boom/Broadcast	Mixer/Loader	1,022	613	204	153	92	31	**0.001**	**0.02**	**0.04**
Ground	ATV/UTV	Boom/Broadcast	Applicator/Mixer/Loader	414	248	83	57	34	11	**0.001**	**0.02**	**0.04**
Ground	Truck Mount	Spot	Applicator	33	20	7	4	2	**0.7**	**0.001**	**0.02**	**0.04**
Ground	Truck Mount	Spot	Mixer/Loader	1,614	968	323	153	92	31	**0.001**	**0.02**	**0.04**
Ground	Truck Mount	Spot	Applicator/Mixer/Loader	32	19	6	4	2	**0.7**	**0.001**	**0.02**	**0.04**
Ground	Truck Mount	Boom/Broadcast	Applicator	679	408	136	142	85	28	**0.001**	**0.02**	**0.04**
Ground	Truck Mount	Boom/Broadcast	Mixer/Loader	545	327	109	91	55	18	**0.001**	**0.02**	**0.04**
Ground	Truck Mount	Boom/Broadcast	Applicator/Mixer/Loader	221	132	44	46	28	9	**0.001**	**0.02**	**0.04**

ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
ATV - All-Terrain Vehicle.
UTV - Utility Vehicle.
(a) - Based on the assumption that a spill of concentrated liquid occurs to worker skin.
(b) - Based on the assumption that a spill to worker skin occurs after concentrated liquid is mixed with water to the maximum application rate.
(c) - Based on the assumption that a spill to worker skin occurs after concentrated liquid is mixed with water to the typical application rate.

Table 5-6
Aggregate Risk Indices - Occupational Scenarios
Herbicide: 2,4-D (Aquatic, Floating and Emerged; Liquid Formulation)
Programs: Aquatic Sites

Application Type	Application Vehicle	Application Method	Receptor	Typical Application Rate Scenario ARIs			Maximum Application Rate Scenario ARIs			Accidental Scenario ARIs (Short-Term Dermal)		
				Short-Term	Intermediate-Term	Long-Term	Short-Term	Intermediate-Term	Long-Term	Concentrated Solution (a)	Mixed (Maximum) Solution (b)	Mixed (Typical) Solution (c)
Aerial	Plane	Fixed Wing	Pilot	17	10	3	2.9	2	**0.6**	**0.002**	**0.009**	**0.02**
Aerial	Plane	Fixed Wing	Mixer/Loader	2	1.5	**0.5**	**0.4**	**0.2**	**0.1**	**0.002**	**0.009**	**0.02**
Aerial	Helicopter	Rotary	Pilot	44	26	9	7	4	1.5	**0.002**	**0.009**	**0.02**
Aerial	Helicopter	Rotary	Mixer/Loader	6	4	1.2	1.02	**0.6**	**0.2**	**0.002**	**0.009**	**0.02**
Ground	Human	Backpack	Applicator/Mixer/Loader	20	12	4	2	1.5	**0.5**	**0.002**	**0.009**	**0.02**
Ground	Human	Horseback	Applicator	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**0.002**	**0.009**	**0.02**
Ground	Human	Horseback	Mixer/Loader	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**0.002**	**0.009**	**0.02**
Ground	Human	Horseback	Applicator/Mixer/Loader	3	2	**0.5**	**0.7**	**0.4**	**0.1**	**0.002**	**0.009**	**0.02**
Ground	ATV/UTV	Spot	Applicator	59	36	12	8	5	2	**0.002**	**0.009**	**0.02**
Ground	ATV/UTV	Spot	Mixer/Loader	3,271	1,962	654	409	245	82	**0.002**	**0.009**	**0.02**
Ground	ATV/UTV	Spot	Applicator/Mixer/Loader	58	35	12	8	5	2	**0.002**	**0.009**	**0.02**
Ground	ATV/UTV	Boom/Broadcast	Applicator	1,274	764	255	177	106	35	**0.002**	**0.009**	**0.02**
Ground	ATV/UTV	Boom/Broadcast	Mixer/Loader	1,022	613	204	153	92	31	**0.002**	**0.009**	**0.02**
Ground	ATV/UTV	Boom/Broadcast	Applicator/Mixer/Loader	414	248	83	57	34	11	**0.002**	**0.009**	**0.02**
Ground	Truck Mount	Spot	Applicator	33	20	7	4	2	**0.7**	**0.002**	**0.009**	**0.02**
Ground	Truck Mount	Spot	Mixer/Loader	1,614	968	323	153	92	31	**0.002**	**0.009**	**0.02**
Ground	Truck Mount	Spot	Applicator/Mixer/Loader	32	19	6	4	2	**0.7**	**0.002**	**0.009**	**0.02**
Ground	Truck Mount	Boom/Broadcast	Applicator	679	408	136	142	85	28	**0.002**	**0.009**	**0.02**
Ground	Truck Mount	Boom/Broadcast	Mixer/Loader	545	327	109	91	55	18	**0.002**	**0.009**	**0.02**
Ground	Truck Mount	Boom/Broadcast	Applicator/Mixer/Loader	221	132	44	46	28	9	**0.002**	**0.009**	**0.02**
Aquatic	Boat	Spot	Applicator	29	18	6	3	2	**0.6**	**0.002**	**0.009**	**0.02**
Aquatic	Boat	Spot	Mixer/Loader	3,894	2,336	779	307	184	61	**0.002**	**0.009**	**0.02**
Aquatic	Boat	Spot	Applicator/Mixer/Loader	29	17	6	3	2	**0.6**	**0.002**	**0.009**	**0.02**
Aquatic	Boat	Boom/Broadcast	Applicator	980	588	196	142	85	28	**0.002**	**0.009**	**0.02**
Aquatic	Boat	Boom/Broadcast	Mixer/Loader	1,887	1,132	377	204	123	41	**0.002**	**0.009**	**0.02**
Aquatic	Boat	Boom/Broadcast	Applicator/Mixer/Loader	318	191	64	46	28	9	**0.002**	**0.009**	**0.02**

ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
ATV - All-Terrain Vehicle.
UTV - Utility Vehicle.
(a) - Based on the assumption that a spill of concentrated liquid occurs to worker skin.
(b) - Based on the assumption that a spill to worker skin occurs after concentrated liquid is mixed with water to the maximum application rate.
(c) - Based on the assumption that a spill to worker skin occurs after concentrated liquid is mixed with water to the typical application rate.

Table 5-7
Aggregate Risk Indices - Occupational Scenarios
Herbicide: 2,4-D (Aquatic, Submerged, Treatment of Volume of Water; Liquid Formulation)
Programs: Aquatic Sites

Application Type	Application Vehicle	Application Method	Receptor	Typical Application Rate Scenario ARIs			Maximum Application Rate Scenario ARIs			Accidental Scenario ARIs (Short-Term Dermal)		
				Short-Term	Intermediate-Term	Long-Term	Short-Term	Intermediate-Term	Long-Term	Concentrated Solution (a)	Mixed (Maximum) Solution (b)	Mixed (Typical) Solution (c)
Aerial	Plane	Fixed Wing	Pilot	6	4	1.3	1.1	**0.6**	**0.2**	**0.002**	**0.003**	**0.01**
Aerial	Plane	Fixed Wing	Mixer/Loader	**0.9**	**0.5**	**0.2**	**0.2**	**0.1**	**0.03**	**0.002**	**0.003**	**0.01**
Aerial	Helicopter	Rotary	Pilot	16	10	3	3	2	**0.5**	**0.002**	**0.003**	**0.01**
Aerial	Helicopter	Rotary	Mixer/Loader	2	1.4	**0.5**	**0.4**	**0.2**	**0.1**	**0.002**	**0.003**	**0.01**
Ground	Human	Backpack	Applicator/Mixer/Loader	7	4	1.5	**0.9**	**0.6**	**0.2**	**0.002**	**0.003**	**0.01**
Ground	Human	Horseback	Applicator/Mixer/Loader	**0.99**	**0.6**	**0.2**	**0.3**	**0.2**	**0.1**	**0.002**	**0.003**	**0.01**
Ground	ATV/UTV	Spot	Applicator	22	13	4	3	2	**0.6**	**0.002**	**0.003**	**0.01**
Ground	ATV/UTV	Spot	Mixer/Loader	1,211	727	242	151	91	30	**0.002**	**0.003**	**0.01**
Ground	ATV/UTV	Spot	Applicator/Mixer/Loader	21	13	4	3	2	**0.6**	**0.002**	**0.003**	**0.01**
Ground	ATV/UTV	Boom/Broadcast	Applicator	472	283	94	66	39	13	**0.002**	**0.003**	**0.01**
Ground	ATV/UTV	Boom/Broadcast	Mixer/Loader	379	227	76	57	34	11	**0.002**	**0.003**	**0.01**
Ground	ATV/UTV	Boom/Broadcast	Applicator/Mixer/Loader	153	92	31	21	13	4	**0.002**	**0.003**	**0.01**
Ground	Truck Mount	Spot	Applicator	12	7	2	1	**0.8**	**0.3**	**0.002**	**0.003**	**0.01**
Ground	Truck Mount	Spot	Mixer/Loader	598	359	120	57	34	11	**0.002**	**0.003**	**0.01**
Ground	Truck Mount	Spot	Applicator/Mixer/Loader	12	7	2	1.3	**0.8**	**0.3**	**0.002**	**0.003**	**0.01**
Ground	Truck Mount	Boom/Broadcast	Applicator	252	151	50	52	31	10	**0.002**	**0.003**	**0.01**
Ground	Truck Mount	Boom/Broadcast	Mixer/Loader	202	121	40	34	20	7	**0.002**	**0.003**	**0.01**
Ground	Truck Mount	Boom/Broadcast	Applicator/Mixer/Loader	82	49	16	17	10	3	**0.002**	**0.003**	**0.01**
Aquatic	Boat	Spot	Applicator	11	7	2	1.1	**0.7**	**0.2**	**0.002**	**0.003**	**0.01**
Aquatic	Boat	Spot	Mixer/Loader	1,442	865	288	114	68	23	**0.002**	**0.003**	**0.01**
Aquatic	Boat	Spot	Applicator/Mixer/Loader	11	6	2	1.1	**0.7**	**0.2**	**0.002**	**0.003**	**0.01**
Aquatic	Boat	Boom/Broadcast	Applicator	363	218	73	52	31	10	**0.002**	**0.003**	**0.01**
Aquatic	Boat	Boom/Broadcast	Mixer/Loader	699	419	140	76	45	15	**0.002**	**0.003**	**0.01**
Aquatic	Boat	Boom/Broadcast	Applicator/Mixer/Loader	118	71	24	17	10	3	**0.002**	**0.003**	**0.01**

ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.

ATV - All-Terrain Vehicle.

UTV - Utility Vehicle.

(a) - Based on the assumption that a spill of concentrated liquid occurs to worker skin.

(b) - Based on the assumption that a spill to worker skin occurs after concentrated liquid is mixed with water to the maximum application rate.

(c) - Based on the assumption that a spill to worker skin occurs after concentrated liquid is mixed with water to the typical application rate.

Table 5-8
Aggregate Risk Indices - Occupational Scenarios
Herbicide: 2,4-D (Aquatic, Submerged, Treatment of pond bottom; Granular Formulation)
Programs: Aquatic Sites

Application Type	Application Vehicle	Application Method	Receptor	Typical Application Rate Scenario ARIs Short-Term	Intermediate-Term	Long-Term	Maximum Application Rate Scenario ARIs Short-Term	Intermediate-Term	Long-Term
Aquatic	Boat	Spot	Applicator/Mixer/Loader	146	88	29	64	38	13
Aquatic	Boat	Boom/Broadcast	Applicator/Mixer/Loader	109	66	22	18	11	4

ARI - Aggregate Risk Index. Values less than one represent a level of concern.

Note that the accidental spill to worker skin scenario is not applicable because this form of 2,4-D is applied as a granular product. Therefore, there is no liquid mixture to be spilled.

Table 5-9
Aggregate Risk Indices - Occupational Scenarios
Herbicide: Fluroxypyr
Programs: Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites

				Typical Application Rate Scenario ARIs			Maximum Application Rate Scenario ARIs			Accidental Scenario ARIs (Short-Term Dermal)
Application Type	**Application Vehicle**	**Application Method**	**Receptor**	**Short-Term**	**Intermediate-Term**	**Long-Term**	**Short-Term**	**Intermediate-Term**	**Long-Term**	**Concentrated Solution (a)**
Aerial	Plane	Fixed Wing	Pilot	4,497	4,497	4,497	779	779	779	NC
Aerial	Plane	Fixed Wing	Mixer/Loader	1,051	1,051	1,051	182	182	182	NC
Aerial	Helicopter	Rotary	Pilot	11,242	11,242	11,242	1,949	1,949	1,949	NC
Aerial	Helicopter	Rotary	Mixer/Loader	2,627	2,627	2,627	455	455	455	NC
Ground	Human	Backpack	Applicator/Mixer/Loader	197,525	197,525	197,525	25,678	25,678	25,678	NC
Ground	Human	Horseback	Applicator/Mixer/Loader	26,337	26,337	26,337	7,703	7,703	7,703	NC
Ground	ATV/UTV	Spot	Applicator	62,722	62,722	62,722	9,060	9,060	9,060	NC
Ground	ATV/UTV	Spot	Mixer/Loader	1,401,004	1,401,004	1,401,004	182,131	182,131	182,131	NC
Ground	ATV/UTV	Spot	Applicator/Mixer/Loader	58,367	58,367	58,367	8,431	8,431	8,431	NC
Ground	ATV/UTV	Boom/Broadcast	Applicator	224,830	224,830	224,830	32,475	32,475	32,475	NC
Ground	ATV/UTV	Boom/Broadcast	Mixer/Loader	437,814	437,814	437,814	68,299	68,299	68,299	NC
Ground	ATV/UTV	Boom/Broadcast	Applicator/Mixer/Loader	121,145	121,145	121,145	17,499	17,499	17,499	NC
Ground	Truck Mount	Spot	Applicator	34,387	34,387	34,387	4,077	4,077	4,077	NC
Ground	Truck Mount	Spot	Mixer/Loader	691,285	691,285	691,285	68,299	68,299	68,299	NC
Ground	Truck Mount	Spot	Applicator/Mixer/Loader	31,999	31,999	31,999	3,794	3,794	3,794	NC
Ground	Truck Mount	Boom/Broadcast	Applicator	119,910	119,910	119,910	25,980	25,980	25,980	NC
Ground	Truck Mount	Boom/Broadcast	Mixer/Loader	233,501	233,501	233,501	40,473	40,473	40,473	NC
Ground	Truck Mount	Boom/Broadcast	Applicator/Mixer/Loader	64,611	64,611	64,611	13,999	13,999	13,999	NC

ARI - Aggregate Risk Index. ARI is based on inhalation exposure because based on the toxicity assessment, dermal exposure is not of concern. Values less than one represent a level of concern.
ATV - All-Terrain Vehicle.
UTV - Utility Vehicle.
NC - Not calculated. Based on toxicity assessment, dermal exposure is not of concern.
(a) - Based on the assumption that a spill of concentrated liquid occurs to worker skin.

Table 5-10
Aggregrate Risk Indices - Occupational Scenarios
Herbicide: Rimsulfuron
Programs: Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites

				Typical Application Rate Scenario ARIs (a) Rangeland, Public-domain Forestland			Maximum Application Rate Scenario ARIs (a) Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites			Accidental Scenario ARIs (Short-Term Dermal)	
Application Type	Application Vehicle	Application Method	Receptor	Short-Term	Intermediate-Term	Long-Term	Short-Term	Intermediate-Term	Long-Term	Mixed (Maximum) Solution (b)	Mixed (Typical) Solution (b)
Aerial	Plane	Fixed Wing	Pilot	87	87	NC	29	29	NC	**0.089**	**0.12**
Aerial	Plane	Fixed Wing	Mixer/Loader	4	4	NC	1.5	1.5	NC	**0.089**	**0.12**
Aerial	Helicopter	Rotary	Pilot	217	217	NC	72	72	NC	**0.089**	**0.12**
Aerial	Helicopter	Rotary	Mixer/Loader	11	11	NC	3.7	3.7	NC	**0.089**	**0.12**
Ground	Human	Backpack	Applicator/Mixer/Loader	94	94	NC	24	24	NC	**0.089**	**0.12**
Ground	Human	Horseback	Applicator/Mixer/Loader	13	13	NC	7	7	NC	**0.089**	**0.12**
Ground	ATV/UTV	Spot	Applicator	283	283	NC	79	79	NC	**0.089**	**0.12**
Ground	ATV/UTV	Spot	Mixer/Loader	5,978	5,978	NC	1,494	1,494	NC	**0.089**	**0.12**
Ground	ATV/UTV	Spot	Applicator/Mixer/Loader	262	262	NC	73	73	NC	**0.089**	**0.12**
Ground	ATV/UTV	Boom/Broadcast	Applicator	6,459	6,459	NC	1,794	1,794	NC	**0.089**	**0.12**
Ground	ATV/UTV	Boom/Broadcast	Mixer/Loader	1,868	1,868	NC	560	560	NC	**0.089**	**0.12**
Ground	ATV/UTV	Boom/Broadcast	Applicator/Mixer/Loader	955	955	NC	265	265	NC	**0.089**	**0.12**
Ground	Truck Mount	Spot	Applicator	155	155	NC	35	35	NC	**0.089**	**0.12**
Ground	Truck Mount	Spot	Mixer/Loader	2,950	2,950	NC	560	560	NC	**0.089**	**0.12**
Ground	Truck Mount	Spot	Applicator/Mixer/Loader	144	144	NC	33	33	NC	**0.089**	**0.12**
Ground	Truck Mount	Boom/Broadcast	Applicator	3,445	3,445	NC	1,435	1,435	NC	**0.089**	**0.12**
Ground	Truck Mount	Boom/Broadcast	Mixer/Loader	996	996	NC	332	332	NC	**0.089**	**0.12**
Ground	Truck Mount	Boom/Broadcast	Applicator/Mixer/Loader	509	509	NC	212	212	NC	**0.089**	**0.12**

ARI - Aggregrate Risk Index. Values less than one represent a level of concern and are highlighted.

NC - Not calculated. Based on toxicity assessment, dermal and inhalation exposures are not of concern.

ATV - All-Terrain Vehicle.

UTV - Utility Vehicle.

(a) - Application rates are shown on Table 4-1 . For rangeland and public-domain forestland, the typical rate is 0.0469 lb a.i./acre and the maximum application rate is 0.0625 lb a.i./acre. For energy and mineral sites, rights-of-way, and recreation and cultural sites the typical and maximum application rates are the same (0.0625 lb a.i./acre). Therefore, the typical application rate scenario is applicable to rangeland and public-domain forestland, and the maximum application rate scenario is applicable to all five land programs.

Table 5-11

Aggregate Risk Indices - Routine Exposure Scenarios for Public Receptors - Short-term Exposure

Herbicide: **Aminopyralid**

Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Typical Application Rate Scenario ARIs (a)						**Maximum Application Rate Scenario ARIs (a)**					
AgDrift Scenario: **Land Type (b):** **Equipment (c):**	**Aerial** **Non-Forested** **Plane**	**Aerial** **Non-Forested** **Helicopter**	**Aerial** **Forested** **Plane**	**Aerial** **Forested** **Helicopter**	**Ground** **Not applicable** **Low Boom**	**Ground** **Not applicable** **High Boom**	**Aerial** **Non-Forested** **Plane**	**Aerial** **Non-Forested** **Helicopter**	**Aerial** **Forested** **Plane**	**Aerial** **Forested** **Helicopter**	**Ground** **Not applicable** **Low Boom**	**Ground** **Not applicable** **High Boom**
Hiker/Hunter (Adult)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Berry Picker (Child)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Berry Picker (Adult)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Angler (Adult)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Residential (Child)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Residential (Adult)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Native American (Child)	9,894,117	9,904,690	9,812,094	9,950,628	9,951,298	9,946,385	7,013,584	7,021,934	6,957,082	7,055,988	7,056,377	7,052,925
Native American (Adult)	19,227,567	19,248,114	19,068,170	19,337,386	19,338,688	19,329,142	13,629,732	13,645,958	13,519,929	13,712,136	13,712,892	13,706,184
Swimmer (Child)	1,982	1,984	1,966	1,994	1,994	1,993	1,405	1,407	1,394	1,414	1,414	1,413
Swimmer (Adult)	17,752	17,771	17,605	17,853	17,855	17,846	12,584	12,599	12,482	12,660	12,660	12,654

ARI - Aggregate Risk Index. Values less than one represent a level of concern. ARI does not include dietary or dermal exposure due to low toxicity (see Table 3-1). ARIs are based on swimming exposure.

NC - Not Calculated. No dose-response values available for dermal exposure or acute dietary exposure due to low toxicity (see Table 3-1).

(a) - Application rates are shown on Table 4-1 and are the same for each program.

(b) - Land type is a parameter used in AgDRIFT to predict aerial spray drift deposition rates and is not applicable to the ground scenarios.

(c) - Low and High Boom applies to a truck-mount or an All-Terrain Vehicle (ATV)-mount boom.

Table 5-12
Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Maximum Herbicide Application Rates
Herbicide: **Aminopyralid**
Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			
Receptor	Spray of Receptor	Contact with Foliage	Spray of Water body (b)	Helicopter Spill	Truck Spill	Spray of Water body (b)	Helicopter Spill	Truck Spill	Spray of Water body (b)	Helicopter Spill	Truck Spill	Berry Ingestion
Angler	NC	NC	--	--	--	NC	NC	NC	NC	NC	NC	--
Berry Picker (Adult)	NC	NC	--	--	--	NC	NC	NC	--	--	--	NC
Berry Picker (Child)	NC	NC	--	--	--	NC	NC	NC	--	--	--	NC
Hiker/Hunter	NC	NC	--	--	--	NC	NC	NC	--	--	--	--
Native American (Adult)	NC	NC	102,250,368	912,950	3,195,324	NC	NC	NC	NC	NC	NC	NC
Native American (Child)	NC	NC	52,615,970	469,785	1,644,249	NC	NC	NC	NC	NC	NC	NC
Residential (Adult)	NC	NC	--	--	--	--	--	--	--	--	--	--
Residential (Child)	NC	NC	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	94,403	843	2,950	--	--	--	--	--	--	--
Swimmer (Child)	--	--	10,542	94	329	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.
ARI - Aggregate Risk Index. Values less than one represent a level of concern.
NC - Not Calculated. No dose-response values available.
(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.
(b) - Assumes accidental spray of non-target water body.

Table 5-13

Aggregate Risk Indices - Routine Exposure Scenarios for Public Receptors - Short-term Exposure

Herbicide: **Clopyralid**

Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Typical Application Rate Scenario ARIs (a)						Maximum Application Rate Scenario ARIs (a)					
AgDrift Scenario: Land Type (b): Equipment (c):	**Aerial Non-Forested Plane**	**Aerial Non-Forested Helicopter**	**Aerial Forested Plane**	**Aerial Forested Helicopter**	**Ground Not applicable Low Boom**	**Ground Not applicable High Boom**	**Aerial Non-Forested Plane**	**Aerial Non-Forested Helicopter**	**Aerial Forested Plane**	**Aerial Forested Helicopter**	**Ground Not applicable Low Boom**	**Ground Not applicable High Boom**
Hiker/Hunter (Adult)	1,107	1,111	1,079	1,126	1,122	1,118	552	554	539	563	561	559
Berry Picker (Child)	383	390	337	420	412	403	189	193	168	210	206	202
Berry Picker (Adult)	893	925	696	1,089	1,045	997	433	454	346	545	522	500
Angler (Adult)	1,075	1,078	1,047	1,093	1,089	1,085	536	538	523	546	544	542
Residential (Child)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Residential (Adult)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Native American (Child)	552	565	466	625	609	592	270	279	232	313	305	297
Native American (Adult)	937	972	722	1,153	1,104	1,051	453	477	359	577	552	527
Swimmer (Child)	3,482	3,493	3,393	3,541	3,528	3,514	1,736	1,743	1,696	1,770	1,764	1,757
Swimmer (Adult)	31,176	31,270	30,375	31,701	31,587	31,464	15,545	15,608	15,182	15,850	15,793	15,732

ARI - Aggregate Risk Index. Values less than one represent a level of concern. ARI does not include dermal exposure due to low toxicity (see Table 3-1).

NC - Not Calculated. No dose-response values available for dermal exposure due to low toxicity (see Table 3-1).

(a) - Application rates are shown on Table 4-1 and are the same for each program.

(b) - Land type is a parameter used in AgDRIFT to predict aerial spray drift deposition rates and is not applicable to the ground scenarios.

(c) - Low and High Boom applies to a truck-mount or an All-Terrain Vehicle (ATV)-mount boom.

Table 5-14

Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Maximum Herbicide Application Rates

Herbicide: **Clopyralid**

Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			
Receptor	**Spray of Receptor**	**Contact with Foliage**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Berry Ingestion**
Angler	NC	NC	--	--	--	532	5	17	17,439	156	545	--
Berry Picker (Adult)	NC	NC	--	--	--	532	5	17	--	--	--	33
Berry Picker (Child)	NC	NC	--	--	--	201	2	6	--	--	--	33
Hiker/Hunter	NC	NC	--	--	--	532	5	17	--	--	--	--
Native American (Adult)	NC	NC	9,281,186	82,868	290,037	1,064	9	33	1,202	11	38	33
Native American (Child)	NC	NC	4,775,911	42,642	149,247	401	4	13	1,202	11	38	33
Residential (Adult)	NC	NC	--	--	--	--	--	--	--	--	--	--
Residential (Child)	NC	NC	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	14,973	134	468	--	--	--	--	--	--	--
Swimmer (Child)	--	--	1,672	15	52	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.
ARI - Aggregate Risk Index. Values less than one represent a level of concern.
NC - Not Calculated. No dose-response values available.
(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.
(b) - Assumes accidental spray of non-target water body.

Table 5-15
Aggregate Risk Indices - Routine Exposure Scenarios for Public Receptors - Short-term Exposure
Herbicide: **2,4-D (Land; Annual and Perennial Species)**
Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Typical Application Rate Scenario ARIs (a)						Maximum Application Rate Scenario ARIs (a)					
AgDrift Scenario: Land Type (b): Equipment (c):	**Aerial Non-Forested Plane**	**Aerial Non-Forested Helicopter**	**Aerial Forested Plane**	**Aerial Forested Helicopter**	**Ground Not applicable Low Boom**	**Ground Not applicable High Boom**	**Aerial Non-Forested Plane**	**Aerial Non-Forested Helicopter**	**Aerial Forested Plane**	**Aerial Forested Helicopter**	**Ground Not applicable Low Boom**	**Ground Not applicable High Boom**
Hiker/Hunter (Adult)	7	8	5	13	12	10	4	4	3	6	6	5
Berry Picker (Child)	3	3	2	5	4	4	1.2	1.4	**0.9**	2	2	2
Berry Picker (Adult)	6	7	4	12	10	9	3	3	2	6	5	4
Angler (Adult)	7	8	5	13	11	10	3	4	3	6	6	5
Residential (Child)	5	6	3	48	20	13	2	3	1.3	25	10	6
Residential (Adult)	12	14	6	111	47	30	5	7	3	59	23	15
Native American (Child)	3	3	2	7	6	5	1.4	2	**0.96**	3	3	2
Native American (Adult)	6	7	4	13	11	9	3	3	2	7	5	4
Swimmer (Child)	43	43	42	44	44	44	21	22	21	22	22	19
Swimmer (Adult)	382	384	370	394	392	390	190	192	185	197	196	172

ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
(a) - Application rates are shown on Table 4-1 and are the same for each program.
(b) - Land type is a parameter used in AgDRIFT to predict aerial spray drift deposition rates and is not applicable to the ground scenarios.
(c) - Low and High Boom applies to a truck-mount or an All-Terrain Vehicle (ATV)-mount boom.

Table 5-16

Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Maximum Herbicide Application Rates

Herbicide: **2,4-D (Land; Annual/Perennial)**

Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

Receptor	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct Spray of Receptor	Dermal Contact with Foliage	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			Berry Ingestion
			Spray of Water body (b)	Helicopter Spill	Truck Spill	Spray of Water body (b)	Helicopter Spill	Truck Spill	Spray of Water body (b)	Helicopter Spill	Truck Spill	
Angler	**0.2**	2	--	--	--	4	**0.04**	**0.1**	145	1.3	5	--
Berry Picker (Adult)	**0.2**	1.29	--	--	--	4	**0.04**	**0.1**	--	--	--	**0.3**
Berry Picker (Child)	**0.1**	**0.7**	--	--	--	2	**0.01**	**0.1**	--	--	--	**0.3**
Hiker/Hunter	**0.2**	2	--	--	--	4	**0.04**	**0.1**	--	--	--	--
Native American (Adult)	**0.2**	1.1	6,457	58	202	9	**0.1**	**0.3**	10	**0.1**	**0.3**	**0.3**
Native American (Child)	**0.1**	**0.6**	3,323	30	104	3	**0.03**	**0.1**	10	**0.1**	**0.3**	**0.3**
Residential (Adult)	**0.2**	**0.3**	--	--	--	--	--	--	--	--	--	--
Residential (Child)	**0.1**	**0.2**	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	124	1.1	4	--	--	--	--	--	--	--
Swimmer (Child)	--	--	14	**0.1**	**0.4**	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.
ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
NC - Not Calculated. No dose-response values available.
(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.
(b) - Assumes accidental spray of non-target water body.

Table 5-17
Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Typical Herbicide Application Rates
Herbicide: **2,4-D (Land; Annual/Perennial)**
Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			
Receptor	**Spray of Receptor**	**Contact with Foliage**	**Spray of Waterbody (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Waterbody (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Waterbody (b)**	**Helicopter Spill**	**Truck Spill**	**Berry Ingestion**
Angler	**0.3**	4	--	--	--	9	**0.1**	**0.3**	291	2.6	9	--
Berry Picker (Adult)	**0.3**	2.58	--	--	--	9	**0.1**	**0.3**	--	--	--	**0.6**
Berry Picker (Child)	**0.1**	1.5	--	--	--	3	**0.03**	**0.1**	--	--	--	**0.6**
Hiker/Hunter	**0.3**	4	--	--	--	9	**0.08**	**0.3**	--	--	--	--
Native American (Adult)	**0.3**	2.1	12,914	115	404	18	**0.2**	**0.6**	20	**0.2**	**0.6**	**0.6**
Native American (Child)	**0.1**	1.2	6,645	59	208	7	**0.1**	**0.2**	20	**0.2**	**0.6**	**0.6**
Residential (Adult)	**0.3**	**0.7**	--	--	--	--	--	--	--	--	--	--
Residential (Child)	**0.1**	**0.4**	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	248	2.21	8	--	--	--	--	--	--	--
Swimmer (Child)	--	--	28	**0.2**	**0.9**	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.
ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
NC - Not Calculated. No dose-response values available.
(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.
(b) - Assumes accidental spray of non-target waterbody.

Table 5-18

Aggregate Risk Indices - Routine Exposure Scenarios for Public Receptors - Short-term Exposure

Herbicide: **2,4-D (Land; Woody Species)**

Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Typical Application Rate Scenario ARIs (a)						**Maximum Application Rate Scenario ARIs (a)**					
AgDrift Scenario: Land Type (b): Equipment (c):	**Aerial Non-Forested Plane**	**Aerial Non-Forested Helicopter**	**Aerial Forested Plane**	**Aerial Forested Helicopter**	**Ground Not applicable Low Boom**	**Ground Not applicable High Boom**	**Aerial Non-Forested Plane**	**Aerial Non-Forested Helicopter**	**Aerial Forested Plane**	**Aerial Forested Helicopter**	**Ground Not applicable Low Boom**	**Ground Not applicable High Boom**
Hiker/Hunter (Adult)	4	4	3	7	6	5	2	2	1.3	3	3	3
Berry Picker (Child)	1.2	1.4	**0.9**	3	2	2	**0.6**	**0.7**	**0.4**	1.3	1.1	**0.96**
Berry Picker (Adult)	3	3	2	6	5	5	1.3	2	**0.9**	3	3	2
Angler (Adult)	4	4	3	7	6	5	2	2	1.3	3	3	3
Residential (Child)	2	3	1.3	25	10	6	1.1	1.3	**0.6**	13	5	3
Residential (Adult)	5	7	3	59	23	15	2	3	1.5	29	11.8	7
Native American (Child)	1.4	2	**0.97**	4	3	3	**0.7**	**0.8**	**0.5**	2	1.5	1.3
Native American (Adult)	3	3	2	7	6	5	1.4	2	**0.9**	3	3	2
Swimmer (Child)	22	22	22	23	23	23	11	11	11	12	11	11
Swimmer (Adult)	198	200	192	206	204	203	99	100	96	103	102	102

ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.

(a) - Application rates are shown on Table 4-1 and are the same for each program.

(b) - Land type is a parameter used in AgDRIFT to predict aerial spray drift deposition rates and is not applicable to the ground scenarios.

(c) - Low and High Boom applies to a truck-mount or an All-Terrain Vehicle (ATV)-mount boom.

Table 5-19

Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Maximum Herbicide Application Rates

Herbicide: **2,4-D (Land; Woody Species)**

Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			
Receptor	**Spray of Receptor**	**Contact with Foliage**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Berry Ingestion**
Angler	**0.1**	1.1	--	--	--	2	**0.02**	**0.1**	73	**0.6**	2	--
Berry Picker (Adult)	**0.1**	**0.6**	--	--	--	2	**0.02**	**0.1**	--	--	--	**0.1**
Berry Picker (Child)	**0.03**	**0.4**	--	--	--	**0.8**	**0.01**	**0.03**	--	--	--	**0.1**
Hiker/Hunter	**0.1**	1.1	--	--	--	2	**0.02**	**0.1**	--	--	--	--
Native American (Adult)	**0.1**	**0.5**	3,228	29	101	4	**0.04**	**0.1**	5	**0.04**	**0.2**	**0.1**
Native American (Child)	**0.03**	**0.3**	1,661	15	52	2	**0.01**	**0.1**	5	**0.04**	**0.2**	**0.1**
Residential (Adult)	**0.1**	**0.2**	--	--	--	--	--	--	--	--	--	--
Residential (Child)	**0.03**	**0.1**	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	62	**0.6**	2	--	--	--	--	--	--	--
Swimmer (Child)	--	--	7	**0.1**	**0.2**	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.

ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.

NC - Not Calculated. No dose-response values available.

(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.

(b) - Assumes accidental spray of non-target water body.

Table 5-20
Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Typical Herbicide Application Rates
Herbicide: **2,4-D (Land; Woody Species)**
Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			
Receptor	Spray of Receptor	Contact with Foliage	Spray of Waterbody (b)	Helicopter Spill	Truck Spill	Spray of Waterbody (b)	Helicopter Spill	Truck Spill	Spray of Waterbody (b)	Helicopter Spill	Truck Spill	Berry Ingestion
Angler	**0.2**	2.2	--	--	--	4	**0.04**	**0.1**	145	1.3	5	--
Berry Picker (Adult)	**0.2**	1.3	--	--	--	4	**0.04**	**0.1**	--	--	--	**0.3**
Berry Picker (Child)	**0.1**	**0.7**	--	--	--	2	**0.01**	**0.1**	--	--	--	**0.3**
Hiker/Hunter	**0.2**	2	--	--	--	4	**0.04**	**0.1**	--	--	--	--
Native American (Adult)	**0.2**	1.1	6,457	58	202	9	**0.1**	**0.3**	10	**0.1**	**0.3**	**0.3**
Native American (Child)	**0.1**	**0.6**	3,323	30	104	3	**0.03**	**0.1**	10	**0.1**	**0.3**	**0.3**
Residential (Adult)	**0.2**	**0.3**	--	--	--	--	--	--	--	--	--	--
Residential (Child)	**0.1**	**0.2**	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	124	1.1	4	--	--	--	--	--	--	--
Swimmer (Child)	--	--	14	**0.1**	**0.4**	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.
ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
NC - Not Calculated. No dose-response values available.
(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.
(b) - Assumes accidental spray of non-target waterbody.

Table 5-21
Aggregate Risk Indices - Routine Exposure Scenarios for Public Receptors - Short-term Exposure
Herbicide: **2,4-D Aquatic (Floating and Emerged)**
Programs: **Aquatic Sites**

	Typical Application Rate Scenario ARIs (a)				**Maximum Application Rate Scenario ARIs (a)**			
AgDrift Scenario: **Land Type (b):** **Equipment (c):**	**Aerial** **Non-Forested** **Plane**	**Aerial** **Non-Forested** **Helicopter**	**Ground** **Not applicable** **Low Boom**	**Ground** **Not applicable** **High Boom**	**Aerial** **Non-Forested** **Plane**	**Aerial** **Non-Forested** **Helicopter**	**Ground** **Not applicable** **Low Boom**	**Ground** **Not applicable** **High Boom**
Hiker/Hunter (Adult)	7	9	31	20	3	4	16	10
Berry Picker (Child)	2	3	10	6	1.05	1	5	3
Berry Picker (Adult)	4	6	20	13	2	3	10	6
Angler (Adult)	7	9	31	20	3	4	16	10
Residential (Child)	2	3	10	6	1.1	1.3	5	3
Residential (Adult)	5	7	23	15	2	3	12	7
Native American (Child)	2	3	10	6	1.04	1.3	5	3
Native American (Adult)	4	6	20	13	2	3	10	6
Swimmer (Child)	557	684	2,294	1,425	262	317	1,143	712
Swimmer (Adult)	4,962	6,093	20,431	12,691	2,335	2,824	10,178	6,344

ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
(a) - Application rates are shown on Table 4-1 and are the same for each program.
(b) - Land type is a parameter used in AgDRIFT to predict aerial spray drift deposition rates and is not applicable to the ground scenarios. The Non-Forested land type is used to model pond concentrations. It is assumed that spray drift settles to an adjacent, non-target pond.
(c) - Low and High Boom applies to a truck-mount or an All-Terrain Vehicle (ATV)-mount boom.

Table 5-22
Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Maximum Herbicide Application Rates
Herbicide: **2,4-D (Aquatic - Floating/Emerged)**
Programs: **Aquatic Sites**

	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			
Receptor	**Spray of Receptor**	**Contact with Foliage**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Berry Ingestion**
Angler	**0.1**	1.1	--	--	--	2	**0.02**	**0.1**	73	**0.6**	2	--
Berry Picker (Adult)	**0.1**	**0.6**	--	--	--	2	**0.02**	**0.1**	--	--	--	**0.1**
Berry Picker (Child)	**0.03**	**0.4**	--	--	--	**0.8**	**0.01**	**0.03**	--	--	--	**0.1**
Hiker/Hunter	**0.1**	1.1	--	--	--	2	**0.02**	**0.1**	--	--	--	--
Native American (Adult)	**0.1**	**0.5**	3,228	29	101	4	**0.04**	**0.1**	5	**0.04**	**0.2**	**0.1**
Native American (Child)	**0.03**	**0.3**	1,661	15	52	2	**0.01**	**0.1**	5	**0.04**	**0.2**	**0.1**
Residential (Adult)	**0.1**	**0.2**	--	--	--	--	--	--	--	--	--	--
Residential (Child)	**0.03**	**0.1**	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	62	**0.6**	2	--	--	--	--	--	--	--
Swimmer (Child)	--	--	7	**0.1**	**0.2**	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.
ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
NC - Not Calculated. No dose-response values available.
(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.
(b) - Assumes accidental spray of non-target water body.

Table 5-23
Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Typical Herbicide Application Rates
Herbicide: **2,4-D (Aquatic - Floating/Emerged)**
Programs: **Aquatic Sites**

	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			
Receptor	**Spray of Receptor**	**Contact with Foliage**	**Spray of Waterbody (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Waterbody (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Waterbody (b)**	**Helicopter Spill**	**Truck Spill**	**Berry Ingestion**
Angler	**0.2**	2	--	--	--	4	**0.04**	**0.1**	145	1.3	5	--
Berry Picker (Adult)	**0.2**	1.3	--	--	--	4	**0.04**	**0.1**	--	--	--	**0.3**
Berry Picker (Child)	**0.1**	**0.7**	--	--	--	2	**0.01**	**0.1**	--	--	--	**0.3**
Hiker/Hunter	**0.2**	2	--	--	--	4	**0.04**	**0.1**	--	--	--	--
Native American (Adult)	**0.2**	1.1	6,457	58	202	9	**0.1**	**0.3**	10	**0.1**	**0.3**	**0.3**
Native American (Child)	**0.1**	**0.6**	3,323	30	104	3	**0.03**	**0.1**	10	**0.1**	**0.3**	**0.3**
Residential (Adult)	**0.2**	**0.3**	--	--	--	--	--	--	--	--	--	--
Residential (Child)	**0.1**	**0.2**	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	124	1.1	4	--	--	--	--	--	--	--
Swimmer (Child)	--	--	14	**0.1**	**0.4**	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.
ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
NC - Not Calculated. No dose-response values available.
(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.
(b) - Assumes accidental spray of non-target waterbody.

Table 5-24
Aggregate Risk Indices - Routine Exposure Scenarios for Public Receptors - Short-term Exposure
Herbicide: **2,4-D Aquatic (Submerged/Volume of Water; Liquid)**
Programs: **Aquatic Sites**

	Typical Application Rate Scenario ARIs (a)				**Maximum Application Rate Scenario ARIs (a)**			
AgDrift Scenario: Land Type (b): Equipment (c):	**Aerial Non-Forested Plane**	**Aerial Non-Forested Helicopter**	**Ground Not applicable Low Boom**	**Ground Not applicable High Boom**	**Aerial Non-Forested Plane**	**Aerial Non-Forested Helicopter**	**Ground Not applicable Low Boom**	**Ground Not applicable High Boom**
Hiker/Hunter (Adult)	2	3	12	7	1.3	2	6	4
Berry Picker (Child)	**0.8**	**0.95**	4	2	**0.4**	**0.5**	2	1.2
Berry Picker (Adult)	2	2	7	5	**0.8**	1.05	4	2
Angler (Adult)	2	3	11	7	1.3	2	6	4
Residential (Child)	**0.8**	**0.97**	4	2	**0.4**	**0.5**	2	1.2
Residential (Adult)	2	2	9	6	**0.97**	1.2	4	3
Native American (Child)	**0.8**	**0.95**	4	2	**0.4**	**0.5**	2	1.2
Native American (Adult)	2	2	7	5	**0.8**	1.04	4	2
Swimmer (Child)	193	232	848	528	99	121	424	264
Swimmer (Adult)	1,716	2,068	7,548	4,700	882	1,075	3,774	2,350

ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
(a) - Application rates are shown on Table 4-1 and are the same for each program.
(b) - Land type is a parameter used in AgDRIFT to predict aerial spray drift deposition rates and is not applicable to the ground scenarios. The Non-Forested land type is used to model pond concentrations. It is assumed that spray drift settles to an adjacent, non-target pond.
(c) - Low and High Boom applies to a truck-mount or an All-Terrain Vehicle (ATV)-mount boom.

Table 5-25

Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Maximum Herbicide Application Rates

Herbicide: **2,4-D (Aquatic - Submerged; Liquid)**

Programs: **Aquatic Sites**

	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			
Receptor	**Spray of Receptor**	**Contact with Foliage**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Berry Ingestion**
Angler	**0.03**	**0.4**	--	--	--	**0.3**	**0.01**	**0.03**	8	**0.2**	**0.8**	--
Berry Picker (Adult)	**0.03**	**0.2**	--	--	--	**0.3**	**0.01**	**0.03**	--	--	--	**0.1**
Berry Picker (Child)	**0.01**	**0.1**	--	--	--	**0.1**	**0.003**	**0.01**	--	--	--	**0.1**
Hiker/Hunter	**0.03**	**0.4**	--	--	--	**0.3**	**0.01**	**0.03**	--	--	--	--
Native American (Adult)	**0.03**	**0.2**	365	11	37	**0.5**	**0.01**	**0.05**	**0.6**	**0.02**	**0.1**	**0.1**
Native American (Child)	**0.01**	**0.1**	188	5	19	**0.2**	**0.01**	**0.02**	**0.6**	**0.02**	**0.1**	**0.1**
Residential (Adult)	**0.03**	**0.1**	--	--	--	--	--	--	--	--	--	--
Residential (Child)	**0.01**	**0.03**	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	7	**0.2**	**0.7**	--	--	--	--	--	--	--
Swimmer (Child)	--	--	**0.8**	**0.02**	**0.1**	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.

ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.

NC - Not Calculated. No dose-response values available.

(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.

(b) - Assumes accidental spray of non-target water body.

Table 5-26
Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Typical Herbicide Application Rates
Herbicide: **2,4-D (Aquatic - Submerged; Liquid)**
Programs: **Aquatic Sites**

Receptor	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct Spray of Receptor	Dermal Contact with Foliage	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			Berry Ingestion
			Spray of Waterbody (b)	Helicopter Spill	Truck Spill	Spray of Waterbody (b)	Helicopter Spill	Truck Spill	Spray of Waterbody (b)	Helicopter Spill	Truck Spill	
Angler	**0.1**	**0.8**	--	--	--	**0.5**	**0.01**	**0.05**	16	**0.5**	1.7	--
Berry Picker (Adult)	**0.1**	**0.5**	--	--	--	**0.5**	**0.01**	**0.05**	--	--	--	**0.1**
Berry Picker (Child)	**0.02**	**0.3**	--	--	--	**0.2**	**0.01**	**0.02**	--	--	--	**0.1**
Hiker/Hunter	**0.1**	**0.8**	--	--	--	**0.5**	**0.01**	**0.05**	--	--	--	--
Native American (Adult)	**0.1**	**0.4**	729	21	75	1.001	**0.03**	**0.1**	1.1	**0.03**	**0.1**	**0.1**
Native American (Child)	**0.02**	**0.2**	375	11	38	**0.4**	**0.01**	**0.04**	1.1	**0.03**	**0.1**	**0.1**
Residential (Adult)	**0.1**	**0.1**	--	--	--	--	--	--	--	--	--	--
Residential (Child)	**0.02**	**0.1**	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	14	**0.4**	1.4	--	--	--	--	--	--	--
Swimmer (Child)	--	--	2	**0.05**	**0.2**	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.
ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
NC - Not Calculated. No dose-response values available.
(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.
(b) - Assumes accidental spray of non-target waterbody.

Table 5-27
Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Maximum Herbicide Application Rates
Herbicide: **2,4-D (Aquatic - Submerged; Granular)**
Programs: **Aquatic Sites**

	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			
Receptor	**Spray of Receptor**	**Contact with Foliage**	**Treatment of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Treatment of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Treatment of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Berry Ingestion**
Angler	--	--	--	--	--	**0.2**	--	--	8	--	--	--
Berry Picker (Adult)	--	--	--	--	--	**0.2**	--	--	--	--	--	--
Berry Picker (Child)	--	--	--	--	--	**0.1**	--	--	--	--	--	--
Hiker/Hunter	--	--	--	--	--	**0.2**	--	--	--	--	--	--
Native American (Adult)	--	--	340	--	--	**0.5**	--	--	**0.5**	--	--	--
Native American (Child)	--	--	175	--	--	**0.2**	--	--	**0.5**	--	--	--
Residential (Adult)	--	--	--	--	--	--	--	--	--	--	--	--
Residential (Child)	--	--	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	7	--	--	--	--	--	--	--	--	--
Swimmer (Child)	--	--	**0.7**	--	--	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.
ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
NC - Not Calculated. No dose-response values available.
(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.
(b) - Granular product (no spray scenario). Assumes receptor enters pond even though warning signs are posted.

Table 5-28

Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Typical Herbicide Application Rates

Herbicide: **2,4-D (Aquatic - Submerged; Granular)**

Programs: **Aquatic Sites**

	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			
Receptor	**Spray of Receptor**	**Contact with Foliage**	**Treatment of Waterbody (b)**	**Helicopter Spill**	**Truck Spill**	**Treatment of Waterbody (b)**	**Helicopter Spill**	**Truck Spill**	**Treatment of Waterbody (b)**	**Helicopter Spill**	**Truck Spill**	**Berry Ingestion**
Angler	--	--	--	--	--	**0.5**	--	--	15	--	--	--
Berry Picker (Adult)	--	--	--	--	--	**0.5**	--	--	--	--	--	--
Berry Picker (Child)	--	--	--	--	--	**0.2**	--	--	--	--	--	--
Hiker/Hunter	--	--	--	--	--	**0.5**	--	--	--	--	--	--
Native American (Adult)	--	--	680	--	--	**0.9**	--	--	1.1	--	--	--
Native American (Child)	--	--	350	--	--	**0.4**	--	--	1.1	--	--	--
Residential (Adult)	--	--	--	--	--	--	--	--	--	--	--	--
Residential (Child)	--	--	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	13	--	--	--	--	--	--	--	--	--
Swimmer (Child)	--	--	1.5	--	--	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.
ARI - Aggregate Risk Index. Values less than one represent a level of concern and are highlighted.
NC - Not Calculated. No dose-response values available.
(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.
(b) - Granular product (no spray scenario). Assumes receptor enters pond even though warning signs are posted.

Table 5-29
Aggregate Risk Indices - Routine Exposure Scenarios for Public Receptors - Short-term Exposure
Herbicide: **Fluroxypyr**
Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Typical Application Rate Scenario ARIs (a)						Maximum Application Rate Scenario ARIs (a)					
AgDrift Scenario: **Land Type (b):** **Equipment (c):**	**Aerial** **Non-Forested** **Plane**	**Aerial** **Non-Forested** **Helicopter**	**Aerial** **Forested** **Plane**	**Aerial** **Forested** **Helicopter**	**Ground** **Not applicable** **Low Boom**	**Ground** **Not applicable** **High Boom**	**Aerial** **Non-Forested** **Plane**	**Aerial** **Non-Forested** **Helicopter**	**Aerial** **Forested** **Plane**	**Aerial** **Forested** **Helicopter**	**Ground** **Not applicable** **Low Boom**	**Ground** **Not applicable** **High Boom**
Hiker/Hunter (Adult)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Berry Picker (Child)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Berry Picker (Adult)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Angler (Adult)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Residential (Child)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Residential (Adult)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Native American (Child)	1,072	975	1,044	1,090	1,086	1,082	556	558	542	567	565	562
Native American (Adult)	2,082	1,895	2,029	2,118	2,110	2,102	1,080	1,084	1,053	1,101	1,097	1,093
Swimmer (Child)	1,724	1,569	1,680	1,754	1,747	1,740	894	898	872	912	909	905
Swimmer (Adult)	4,776	4,347	4,653	4,858	4,840	4,821	2,477	2,487	2,414	2,526	2,517	2,507

ARI - Aggregate Risk Index. Values less than one represent a level of concern. ARI does not include dermal or dietary exposure due to low toxicity. See Table 3-1. ARIs are based on swimming exposure.
NC - Not Calculated. No dose-response values available for dermal exposure or acute dietary exposure due to low toxicity (see Table 3-1).
(a) - Application rates are shown on Table 4-1 and are the same for each program.
(b) - Land type is a parameter used in AgDRIFT to predict aerial spray drift deposition rates and is not applicable to the ground scenarios.
(c) - Low and High Boom applies to a truck-mount or an All-Terrain Vehicle (ATV)-mount boom.

Table 5-30

Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Maximum Herbicide Application Rates

Herbicide: **Fluroxypyr**

Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			
Receptor	**Spray of Receptor**	**Contact with Foliage**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Spray of Water body (b)**	**Helicopter Spill**	**Truck Spill**	**Berry Ingestion**
Angler	NC	NC	--	--	--	NC	NC	NC	NC	NC	NC	--
Berry Picker (Adult)	NC	NC	--	--	--	NC	NC	NC	--	--	--	NC
Berry Picker (Child)	NC	NC	--	--	--	NC	NC	NC	--	--	--	NC
Hiker/Hunter	NC	NC	--	--	--	NC	NC	NC	--	--	--	--
Native American (Adult)	NC	NC	1,027	9	32	NC	NC	NC	NC	NC	NC	NC
Native American (Child)	NC	NC	528	5	17	NC	NC	NC	NC	NC	NC	NC
Residential (Adult)	NC	NC	--	--	--	--	--	--	--	--	--	--
Residential (Child)	NC	NC	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	2,355	21	74	--	--	--	--	--	--	--
Swimmer (Child)	--	--	850	8	27	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.

ARI - Aggregate Risk Index. Values less than one represent a level of concern.

NC - Not Calculated. No dose-response values available.

(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.

(b) - Assumes accidental spray of non-target water body.

Table 5-31
Aggregate Risk Indices - Routine Exposure Scenarios for Public Receptors - Short-term Exposure
Herbicide: **Rimsulfuron**
Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Typical Application Rate Scenario ARIs (a) Rangeland, Public-domain Forestland						Maximum Application Rate Scenario ARIs (a) Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites					
AgDrift Scenario:	**Aerial**	**Aerial**	**Aerial**	**Aerial**	**Ground**	**Ground**	**Aerial**	**Aerial**	**Aerial**	**Aerial**	**Ground**	**Ground**
Land Type (b):	**Non-Forested**	**Non-Forested**	**Forested**	**Forested**	**Not applicable**	**Not applicable**	**Non-Forested**	**Non-Forested**	**Forested**	**Forested**	**Not applicable**	**Not applicable**
Equipment (c):	**Plane**	**Helicopter**	**Plane**	**Helicopter**	**Low Boom**	**High Boom**	**Plane**	**Helicopter**	**Plane**	**Helicopter**	**Low Boom**	**High Boom**
Hiker/Hunter (Adult)	252	305	59	713	2,139	1,426	178	225	47	535	1,426	328
Berry Picker (Child)	96	116	23	271	813	542	68	86	18	203	542	125
Berry Picker (Adult)	241	291	57	681	2,043	1,362	170	215	45	511	1,362	313
Angler (Adult)	252	305	59	713	2,139	1,426	178	225	47	535	1,426	328
Residential (Child)	79	95	19	222	667	445	56	70	15	167	445	102
Residential (Adult)	183	222	43	518	1,553	1,036	129	163	34	388	1,036	238
Native American (Child)	94	114	22	267	801	534	67	84	18	200	534	123
Native American (Adult)	236	285	56	667	2,000	1,333	167	210	44	500	1,333	307
Swimmer (Child)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Swimmer (Adult)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

ARI - Aggregate Risk Index. Values less than one represent a level of concern.
NC - Not Calculated. No dose-response value available for incidental oral pathway due to use pattern (see Table 3-1).
(a) - Application rates are shown on Table 4-1 . For rangeland and public-domain forestland, the typical rate is 0.0469 lb a.i./acre and the maximum application rate is 0.0625 lb a.i./acre. For energy and mineral sites, rights-of-way, and recreation and cultural sites the typical and maximum application rates are the same (0.0625 lb a.i./acre). Therefore, the typical application rate scenario is applicable to rangeland and public-domain forestland, and the maximum application rate scenario is applicable to all five land programs.
(b) - Land type is a parameter used in AgDRIFT to predict aerial spray drift deposition rates and is not applicable to the ground scenarios.
(c) - Low and High Boom applies to a truck-mount or an All-Terrain Vehicle (ATV)-mount boom.

Table 5-32
Aggregate Risk Indices for Accidental Exposure Scenarios for Public Receptors Based on Maximum Herbicide Application Rates
Herbicide: **Rimsulfuron**
Programs: **Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, and Recreation and Cultural Sites**

	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming (a)			Drinking Water Ingestion			Fish Ingestion			
Receptor	Spray of Receptor	Contact with Foliage	Spray of Water body (b)	Helicopter Spill	Truck Spill	Spray of Water body (b)	Helicopter Spill	Truck Spill	Spray of Water body (b)	Helicopter Spill	Truck Spill	Berry Ingestion
Angler	12	104	--	--	--	NC	NC	NC	NC	NC	NC	--
Berry Picker (Adult)	7	61	--	--	--	NC	NC	NC	--	--	--	NC
Berry Picker (Child)	3	35	--	--	--	NC	NC	NC	--	--	--	NC
Hiker/Hunter	7	104	--	--	--	NC	NC	NC	--	--	--	--
Native American (Adult)	7	51	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Native American (Child)	3	29	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Residential (Adult)	7	15	--	--	--	--	--	--	--	--	--	--
Residential (Child)	3	9	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	NC	NC	NC	--	--	--	--	--	--	--
Swimmer (Child)	--	--	NC	NC	NC	--	--	--	--	--	--	--

-- Receptor not exposed via this pathway.
ARI - Aggregate Risk Index. Values less than one represent a level of concern.
NC - Not Calculated. No dose-response values available.
(a) - Includes incidental ingestion for the swimmer. Incidental ingestion is not included for the Native American receptor because the drinking water pathway is included.
(b) - Assumes accidental spray of non-target water body.

Table 5-33
Routine Public Scenarios/Receptors with Aggregate Risk Indices below One

AgDrift Scenario: Land Type (a): Equipment (b):	Routine Exposure Scenarios with Aggregate Risk Index below One (c,d)											
	Typical Application Rate Scenario ARIs						Maximum Application Rate Scenario ARIs					
	Aerial Non-Forested Plane	**Aerial Non-Forested Helicopter**	**Aerial Forested Plane**	**Aerial Forested Helicopter**	**Ground Not Applicable Low Boom**	**Ground Not Applicable High Boom**	**Aerial Non-Forested Plane**	**Aerial Non-Forested Helicopter**	**Aerial Forested Plane**	**Aerial Forested Helicopter**	**Ground Not Applicable Low Boom**	**Ground Not Applicable High Boom**
Hiker/Hunter (Adult)	2,4-D (S): L	2,4-D (S): L	2,4-D (W): L	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (W): I,L 2,4-D (FE): L 2,4-D (S): I,L	2,4-D (W): I,L 2,4-D (FE): L 2,4-D (S): I,L	2,4-D (AP): L 2,4-D (W): I,L	*No ARI<1*	*No ARI<1*	2,4-D (W): I 2,4-D (S): L
Berry Picker (Child)	2,4-D (AP): I,L 2,4-D (W): I,L 2,4-D (FE): I,L 2,4-D (S): S,I,L	2,4-D (AP): I 2,4-D (W): I,L 2,4-D (FE): L 2,4-D (S): S,I,L	2,4-D (AP): I,L 2,4-D (W): S,I,L	2,4-D (W): I	2,4-D (W): I 2,4-D (S): L	2,4-D (W): I 2,4-D (S): L	2,4-D (AP): I,L 2,4-D (W): S,I,L 2,4-D (FE): I,L 2,4-D (S): S,I,L	2,4-D (AP): I,L 2,4-D (W): S,I,L 2,4-D (FE): I,L 2,4-D (S): S,I,L	2,4-D (AP): S,I,L 2,4-D (W): S,I,L	2,4-D (AP): I 2,4-D (W): I	2,4-D (AP): I 2,4-D (W): I,L 2,4-D (FE): L 2,4-D (S): I,L	2,4-D (AP): I,L 2,4-D (W): I,L 2,4-D (FE): L 2,4-D (S): I,L
Berry Picker (Adult)	2,4-D (W): I,L 2,4-D (FE): L 2,4-D (S): I,L	2,4-D (S): I,L	2,4-D (W): I,L	*No ARI<1*	*No ARI<1*	2,4-D (S): L	2,4-D (AP): I,L 2,4-D (W): I,L 2,4-D (FE): I,L 2,4-D (S): S,I,L	2,4-D (W): I,L 2,4-D (FE): I,L 2,4-D (S): I,L	2,4-D (AP): I,L 2,4-D (W): S,I,L	*No ARI<1*	2,4-D (W): I 2,4-D (S): L	2,4-D (W): S,I 2,4-D (S): I,L
Angler (Adult)	2,4-D (S): L	2,4-D (S): L	2,4-D (W): L	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (W): I,L 2,4-D (FE): L 2,4-D (S): I,L	2,4-D (W): I,L 2,4-D (FE): L 2,4-D (S): I,L	2,4-D (AP): L 2,4-D (W): I,L	*No ARI<1*	2,4-D (W): I	2,4-D (W): I 2,4-D (S): L
Residential (Child)	2,4-D (W): L 2,4-D (FE): L 2,4-D (S): S,I,L	2,4-D (W): L 2,4-D (FE): L 2,4-D (S): S,I,L	2,4-D (AP): L 2,4-D (W): I,L	*No ARI<1*	2,4-D (S): L	2,4-D (S): L	2,4-D (AP): L 2,4-D (W): I,L 2,4-D (FE): I,L 2,4-D (S): S,I,L	2,4-D (AP): L 2,4-D (W): I,L 2,4-D (FE): I,L 2,4-D (S): S,I,L	2,4-D (AP): I,L 2,4-D (W): S,I,L	*No ARI<1*	2,4-D (S): L	2,4-D (W): L 2,4-D (FE): L 2,4-D (S): I,L
Residential (Adult)	2,4-D (S): L	2,4-D (S): L	2,4-D (W): L	*No ARI<1*	*No ARI<1*	2,4-D (S): L	2,4-D (W): L 2,4-D (FE) - L 2,4-D (S): S,I,L	2,4-D (W): L 2,4-D (FE): L 2,4-D (S): I,L	2,4-D (AP): L 2,4-D (W): I,L	*No ARI<1*	2,4-D (S): L	2,4-D (S): L
Native American (Child)	2,4-D (AP): L 2,4-D (W): I,L 2,4-D (FE): I,L 2,4-D (S): S,I,L	2,4-D (W): I,L 2,4-D (FE): L 2,4-D (S): S,I,L	2,4-D (AP): I,L 2,4-D (W): S,I,L	*No ARI<1*	2,4-D (S): L	2,4-D (W): I 2,4-D (S): L	2,4-D (AP): I,L 2,4-D (W): S,I,L 2,4-D (FE): I, L 2,4-D (S): S,I,L	2,4-D (AP): I,L 2,4-D (W): S,I,L 2,4-D (FE): I, L 2,4-D (S): S,I,L	2,4-D (AP): S,I,L 2,4-D (W): S,I,L	2,4-D (W): I	2,4-D (AP): I 2,4-D (W): I,L 2,4-D (FE): L 2,4-D (S): I,L	2,4-D (AP): I,L 2,4-D (W): I,L 2,4-D (FE): L 2,4-D (S): I,L
Native American (Adult)	2,4-D (W): I,L 2,4-D (FE): L 2,4-D (S): I,L	2,4-D (S): I,L	2,4-D (W): I,L	*No ARI<1*	*No ARI<1*	2,4-D (S): L	2,4-D (AP): I,L 2,4-D (W): I,L 2,4-D (FE): I,L 2,4-D (S): S,I,L	2,4-D (W): I,L 2,4-D (FE): I,L 2,4-D (S): I,L	2,4-D (AP): I,L 2,4-D (W): S,I,L	*No ARI<1*	2,4-D (W): I 2,4-D (S): L	2,4-D (W): I 2,4-D (S): I,L
Swimmer (Adult)	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*
Swimmer (Child)	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*

ARI - Aggregate Risk Index.
(a) - Non-forested land type is used as a proxy for a pond for aerial scenarios. Ground scenarios are not differentiated in AgDRIFT by land type.
(b) - Low and High Boom applies to a truck mount or a boat mount boom.
(c) - ARI values less than one indicate a level of concern.
(d) - Herbicides evaluated include: aminopyralid, clopyralid, 2,4-D, fluroxypyr, and rimsulfuron.

2,4-D (AP) - 2,4-D (Land; Annual/Perennial Species)
2,4-D (W) - 2,4-D (Land; Woody Species)
2,4-D (FE) - 2,4-D (Aquatic, Floating and Emerged)
2,4-D (S) - 2,4-D (Aquatic, Submerged, Treatment of Volume of Water)

S - Short-term exposure
I - Intermediate-term exposure
L - Long-term exposure

6.0 SUMMARY AND CONCLUSIONS

The HHRA has been conducted to evaluate potential risks to human health that may result from exposure to the herbicide active ingredients both during and after treatment of public lands. The HHRA has evaluated the following five herbicide active ingredients:

- Aminopyralid
- Clopyralid
- 2,4-D
- Fluroxypyr
- Rimsulfuron

These active ingredients may be formulated into herbicides under a variety of trade names and manufacturers. Therefore, specific trade names and manufacturers are not discussed in this report, other than to reference herbicide labels (Appendix A).

The HHRA follows the four-step risk assessment paradigm as identified by NAS (1983):

- Hazard Identification
- Dose-Response Assessment
- Exposure Assessment
- Risk Characterization

6.1 Hazard Identification

The Hazard Identification section provides information on the herbicide active ingredient characteristics, usage, and toxicity profiles. The toxicity profiles include information on acute, subchronic, and chronic toxicity studies, reproductive and developmental toxicity studies, results of cancer bioassays, mutagenesis, and metabolism. The USEPA has developed toxicity categories for pesticides based on acute toxicity animal tests conducted as part of the process of pesticide registration. The toxicity categories are I, II, III and IV representing severe, moderate, slight and very slight toxicity, respectively. The criteria considered are oral, inhalation, and dermal acute toxicity, eye irritation, skin irritation and dermal sensitization. For most of the criteria, the herbicide active ingredients are in toxicity categories III and IV. Aminopyralid, clopyralid, and 2,4-D are in category I for eye irritation, and fluroxypyr is in category II for acute inhalation. None of the five herbicide active ingredients are designated as potential carcinogens by the USEPA.

6.2 Dose-response Assessment

The dose-response assessment involves identifying the types of health effects potentially related to exposure of each of the herbicide active ingredients. Health effects are categorized as potentially carcinogenic or noncarcinogenic. None of the herbicide active ingredients are categorized as potential carcinogens. Therefore, the dose-response assessment is focused on noncarcinogenic effects.

For pesticide risk assessments, noncarcinogenic effects are evaluated differently depending on whether the exposure is dietary or non-dietary. Dietary exposures are evaluated by dividing site-specific herbicide active ingredient intakes by the PAD. The results are expressed as %PADs. The %PAD approach was used to evaluate public receptor ingestion of drinking water and eating berries and fish. Non-dietary exposures are evaluated by dividing the NOAEL by the site-specific intake to calculate an MOE. The MOEs are typically compared to a target MOE of 100, unless specified otherwise. NOAELs are available for a variety of exposure durations and exposure routes. The NOAEL approach is used to evaluate the occupational receptors and the public receptors for the following scenarios: dermal contact with spray, dermal contact with foliage, dermal contact with water while swimming, and incidental ingestion of water while swimming.

For each of the five herbicide active ingredients evaluated in this HHRA, the USEPA has developed NOAELs for a majority but not all of exposure durations and exposure routes. Where NOAELs are not available, it is because the herbicide active ingredient has not been shown to be toxic for that exposure route or because the exposure duration is not applicable. NOAELs were obtained from the USEPA's HED risk assessments used to support herbicide registration.

6.3 Exposure Assessment

The exposure assessment involves identifying receptors and exposure scenarios and quantifying exposures. To understand how humans may be exposed to herbicide active ingredients as a result of the BLM vegetation treatment program, it is necessary to understand herbicide use within the BLM. Within the BLM vegetation treatment program, public lands are classified into various land programs (Rangeland, Public-domain Forestland, Energy and Mineral Sites, Rights-of-way, Recreation and Cultural sites, and Riparian and Aquatic sites). Within each program, aerial-, ground- or boat-based applications may be used. Various application vehicles can be used for each application type, and for each vehicle, there are different application methods. Similarly, there are different BLM job descriptions associated with each application method. It is assumed that occupational receptors may be incidentally exposed to the herbicide active ingredient used through dermal contact and inhalation exposure routes. In addition, an accidental spill scenario was evaluated for the occupational receptors, assuming a direct spill of herbicide active ingredient onto the skin.

Members of the public may also be incidentally exposed to herbicide active ingredients used on public lands. Such receptors include hikers, hunters, berry pickers, swimmers, anglers, nearby residents, and Native Americans using natural resources on public lands. Although there are many different exposure scenarios and receptors that could be evaluated, these receptors cover a range of potential exposures that could occur under worst-case conditions on BLM lands. It is assumed that these receptors could be exposed through one or more of the following exposure pathways:

- Dermal contact with spray
- Dermal contact with foliage
- Dermal contact with water while swimming
- Ingestion of drinking water or incidental ingestion of water while swimming
- Ingestion of berries
- Ingestion of fish

Although all public receptor exposures to herbicide active ingredients used on public lands are considered to be accidental, public receptor exposures are evaluated under two scenarios. Routine-use exposures are assumed to occur when public receptors come into contact with environmental media that have been impacted by spray drift. Dose-response values are available for short-, intermediate-, and long-term exposures. While it is possible that public receptors use public lands under intermediate- and long-term time frames, it is unlikely that public receptors would be exposed to herbicides under the routine-use scenario for more than a short-term exposure, which is defined as up to 30 days (USEPA 2012a). Therefore, short-term dose-response values were used to evaluate the public receptors under the routine-use exposure scenario. An evaluation of the public receptors under an intermediate- and a long-term exposure scenario is included in the Uncertainty Analysis (Section 5.4).

Accidental exposures are assumed to occur when public receptors come into contact with environmental media that have been subject to direct spray or spills. Under the direct spray scenarios, it is assumed that a receptor enters a foliated area or a pond (for the aquatic herbicide active ingredients) that has recently been treated, even though the area is posted with warning signs. The direct spray pathway for terrestrial herbicide active ingredients onto ponds assumes that the herbicide active ingredients are accidentally sprayed on the pond.

To quantify exposures, it is necessary to estimate the herbicide active ingredient concentrations to which receptors could be exposed. For the occupational receptors, routine exposures were calculated using unit exposure values developed by the USEPA combined with the herbicide active ingredient application rates and the acres treated per day. Accidental exposures were calculated using the undiluted herbicide active ingredient concentrations for liquid formulations and application-ready concentrations for solid formulations, and assuming a certain amount of spill and absorption through the skin.

For the public receptors, routine exposures from spray drift were calculated using EPCs developed using computer models. The AgDRIFT® model was used to estimate deposition of herbicide active ingredient drift onto the receptor, foliage, berries, and pond. The GLEAMS model was used to calculate herbicide active ingredient concentrations in the pond resulting from runoff (short-, intermediate- and long-term exposure durations). For the terrestrial herbicide active ingredients, pond concentrations calculated in AgDRIFT® were added to the highest pond concentrations calculated in GLEAMS. Accidental exposures were calculated assuming direct spray of the herbicide active ingredients at the maximum application rates onto the receptor, foliage, berries, and pond. In addition, an accidental spill scenario was evaluated for the pond assuming that the entire contents of a truck or helicopter could spill into the pond.

6.4 Risk Characterization

The risk characterization section provides quantitative risk estimates for each of the herbicide active ingredients for the various receptors and exposure scenarios. The USEPA's OPP has developed an ARI approach that combines risks calculated using the %PAD and MOE methods. As with the MOE, potential risk increases as the ARI decreases. The ARI is compared against a target value of 1. Values greater than 1 do not exceed the USEPA's level of concern, indicating no adverse health effects are expected. Values less than 1 exceed the USEPA's level of concern, indicating the potential for health risks.

Table 6-1 shows the scenarios and herbicide active ingredients resulting in ARIs less than 1 for the occupational receptors for both routine and accidental exposures scenarios. As shown in Table 6-1, ARIs are less than 1, indicating an exceedance of the USEPA's level of concern, for several formulations of 2,4-D. A summary of the findings is presented below:

Under the typical application rate scenarios, the following did not exceed the USEPA's level of concern, indicating that no adverse health effects are expected:

- Aminopyralid in any application, receptor, or time-frame scenario combinations.
- Clopyralid in any application, receptor, or time-frame scenario combinations.
- Fluroxypyr in any application, receptor, or time-frame scenario combinations.
- Rimsulfuron in any application, receptor, or time-frame scenario combinations.

- 2,4-D in any formulations, application, or receptor under the short- or intermediate-term exposure scenario, with the exception of an airplane mixer/loader and a horseback applicator/mixer/loader using the liquid 2,4-D formulation to treat submerged vegetation in a volume of water.

- 2,4-D in any formulations, application, or receptor under the long-term exposure scenario combinations, with the exceptions listed below (note that the USEPA determined that the long-term exposure scenario is an unlikely one for the BLM vegetation treatment program):

    - An airplane mixer/loader using any of the liquid formulations of 2,4-D.

    - A helicopter mixer/loader using the liquid 2,4-D formulation to treat submerged vegetation in a volume of water.

    - A horseback applicator/mixer/loader using liquid 2,4-D formulations to treat woody species in terrestrial environments, floating and emerged vegetation in an aquatic environment, and submerged vegetation in a volume of water.

Under the maximum application rate scenario, the following did not exceed USEPA's level of concern, indicating that no adverse health effects are expected:

- Aminopyralid in any application, receptor, or time-frame scenario combinations.

- Clopyralid in any application, receptor, or time-frame scenario combinations.

- Fluroxypyr in any application, receptor, or time-frame scenario combinations.

- Rimsulfuron in any application, receptor, or time-frame scenario combinations.

The following 2,4-D maximum application rate scenarios did exceed USEPA's level of concern for human health (note that the USEPA determined that the long-term exposure scenario is an unlikely one for the BLM vegetation treatment program):

- An airplane pilot using the liquid 2,4-D formulation to treat submerged vegetation in a volume of water for intermediate- and long-term exposures and the liquid 2,4-D formulation to treat woody species on terrestrial environments and floating and emerged species in aquatic environments for long-term exposures.

- An airplane mixer/loader using any of the liquid formulations of 2,4-D under short-, intermediate-, and long-term exposures.

- A helicopter pilot using the liquid 2,4-D formulation to treat submerged vegetation in a volume of water for long-term exposures.

- A helicopter mixer/loader using the liquid 2,4-D formulation to treat submerged vegetation in a volume of water for short-, intermediate-, and long-term exposures, the liquid 2,4-D formulations to treat woody species on terrestrial environments and floating and emerged species in aquatic environments for intermediate- and long-term exposures, and the liquid 2,4-D formulation to treat annual/perennial species in terrestrial environments for long-term exposures.

- A backpack applicator/mixer/loader using the liquid 2,4-D formulation to treat submerged vegetation in a volume of water for short-, intermediate-, and long-term exposures and the liquid 2,4-D formulations to treat annual and perennial species on terrestrial environments, woody species on terrestrial environments and floating and emerged species in aquatic environments for long-term exposures.

- A horseback applicator/mixer/loader using the liquid 2,4-D formulations to treat woody species on terrestrial environments, floating and emerged species in aquatic environments, and submerged vegetation in a volume of water for short-, intermediate-, and long-term exposures and the liquid 2,4-D formulation to treat annual and perennial species on terrestrial environments for long-term exposures.

- An ATV/UTV spot applicator or applicator/mixer/loader loader using the liquid 2,4-D formulation to treat submerged vegetation in a volume of water for long-term exposures.

- A truck spot applicator or spot applicator/mixer/loader using the liquid 2,4-D formulation to treat submerged vegetation in a volume of water for intermediate- and long-term exposures and the liquid 2,4-D formulation to treat woody species on terrestrial environments and floating and emerged species in aquatic environments for long-term exposures.

- A boat spot applicator or spot applicator/mixer/loader using the liquid 2,4-D formulation to treat submerged vegetation in a volume of water for intermediate- and long-term exposures and the liquid 2,4-D formulation to treat floating and emerged species in aquatic environments for long-term exposures.

The accidental spill of 0.5 L solution to worker skin scenario results in exceedances of the USEPA's level of concern for human health for all occupational receptors evaluated under both typical and maximum application rate scenarios for 2,4-D and rimsulfuron. These scenarios conservatively assume that PPE does not prevent dermal exposure.

Table 6-2 shows the routine-use scenarios and herbicide active ingredients resulting in ARIs of less than 1 for the public receptors. As shown in Table 6-2, some ARIs are less than 1, indicating an exceedance of the USEPA's level of concern for human health, for several formulations of 2,4-D. A summary of the findings is presented below:

Under the typical application rate scenarios, the following did not exceed the USEPA's level of concern, indicating that no adverse health effects are expected:

- Aminopyralid in any application or receptor combination.

- Clopyralid in any application or receptor combination.

- Fluroxypyr in any application or receptor combination.

- Rimsulfuron in any application or receptor combination.

- The liquid formulation of 2,4-D used to treat annual and perennial species in terrestrial environments in any application or receptor combinations.

- The liquid formulation of 2,4-D used to treat floating and emerged species in aquatic environments in any application or receptor combinations.

- 2,4-D in any application under the following receptor scenarios: hiker/hunter, angler adult, berry picker adult, Native American adult, residential adult, and the swimmer adult or child (note that public receptors are not expected to be exposed to the granular formulation of 2,4-D used to treat submerged vegetation on pond bottoms).

- Also note that the following application methods did not exceed USEPA's level of concern for any herbicide evaluated: helicopter application in forested terrain, and both low- and high-boom ground applications.

Under the typical application rate scenario, the formulation of 2,4-D used to treat submerged vegetation in a volume of water exceeds the USEPA's level of concern for human health for the berry picker child, the residential child, and the Native American child under the airplane and helicopter application scenarios (non-forested terrain used for pond scenario for evaluation of aquatic formulations). The formulation of 2,4-D used to treat woody species in terrestrial environments exceeds the USEPA's level of concern for the berry picker child and the Native American child under the airplane application scenario in forested terrain.

Under the maximum application rate scenarios, the following did not exceed the USEPA's level of concern, indicating that no adverse health effects are expected:

- Aminopyralid in any application or receptor combination.
- Clopyralid in any application or receptor combination.
- Fluroxypyr in any application or receptor combination.
- Rimsulfuron in any application or receptor combination.
- The liquid formulation of 2,4-D used to treat floating and emerged species in aquatic environments in any application or receptor combinations.
- 2,4-D in any application under the following receptor scenarios: hiker/hunter, angler adult, and the swimmer adult or child (note that public receptors are not expected to be exposed to the granular formulation of 2,4-D used to treat submerged vegetation on pond bottoms).
- Also note that the following application methods did not exceed USEPA's level of concern for any herbicide evaluated: helicopter application in forested terrain and low boom ground applications.

Under the maximum application rate scenario, exceedances of the USEPA's level of concern for human health were identified for three of the liquid formulations of 2,4-D as indicated below:

- The liquid formulation of 2,4-D used to treat annual and perennial species in terrestrial environments for the berry picker child and Native American child under the airplane application scenario in forested terrain.
- The liquid formulation of 2,4-D used to treat woody species in terrestrial environments for the berry picker child and Native American child under the airplane and helicopter application scenarios in non-forested terrain and the airplane application scenario in forested terrain, the berry picker adult, the residential child, and the Native American adult under the airplane application scenario in forested terrain, and the berry picker child under the ground high-boom scenario.
- The liquid formulation of 2,4-D used to treat submerged vegetation in a volume of water for the berry picker adult and child, the Native American adult and child, and the residential adult and child under the airplane scenario, and the berry picker child, the Native American child, and the residential child under the helicopter application scenario. The non-forested scenario was used to represent applications on ponds.

Table 6-3 presents a summary of accidental use scenarios and herbicide active ingredients resulting in ARIs less than 1 for the public receptors. A summary of the findings is presented below.

Under the accidental exposure scenarios, the following did not exceed USEPA's level of concern, indicating that no adverse health effects are expected:

- Aminopyralid in any receptor or scenario combination.
- Clopyralid in any receptor or scenario combination.
- Fluroxypyr in any receptor or scenario combination.

- Rimsulfuron in any receptor or scenario combination.

As indicated on the table, exceedances of the USEPA's level of concern for human health were identified for all five formulations of 2,4-D for at least one receptor/scenario. See Table 6-3 for a specific listing of the receptors and scenarios resulting in exceedances.

6.5 Comparison of Previous Results to Current Results

Two of the herbicide active ingredients evaluated in this HHRA are used on BLM lands and were incorporated by reference. The BLM previously relied on Forest Service risk assessments for both clopyralid (SERA 2004) and 2,4-D (SERA 2006).

The methods used by the Forest Service and the BLM to evaluate potential risks from herbicide active ingredients are similar in the basic premise and theory, but different regarding specific methodology. A detailed comparison of the methodology may be found in the Forest Service document *Preparation of Environmental Documentation and Risk Assessments for the USDA/Forest Service* (SERA 2007). Despite the differences in methodology, the results of the risk assessments are similar, as discussed below.

The results of the Forest Service HHRA for clopyralid are similar to the results identified in this HHRA, in which no unacceptable risks were identified. The Forest Service HHRA did not identify unacceptable risks for occupational receptors under routine or accidental scenarios, or for public receptors under routine scenarios. The Forest Service did identify one scenario that resulted in a slight exceedance of the level of concern, for a child drinking water from a pond that had received a spill of clopyralid. The Forest Service evaluated a range of potential exposure scenarios and this exceedance occurred only at the upper estimate.

The Forest Service HHRA for 2,4-D identified potentially unacceptable risks from 2,4-D to occupational receptors. The Forest Service also identified unacceptable risks from accidental exposure to 2,4-D (direct spray of child, ingestion of water from a water body receiving a spill, and ingestion of fish from a water body receiving a spill). In addition, potentially unacceptable risks were identified based on ingesting contaminated fruits and vegetables. These results are not substantially different from those identified in this HHRA; however, this HHRA does identify additionally potentially unacceptable risks under routine (spray drift) exposure scenarios.

6.6 Summary

These results show that aminopyralid, clopyralid, fluroxypyr, and rimsulfuron do not pose unacceptable risks for any of the occupational or public exposure scenarios evaluated under routine use scenarios; rimsulfuron poses potentially unacceptable risks to occupational receptors under an accidental spill to skin scenario. Potentially unacceptable risks were identified for 2,4-D for a variety of uses and scenarios. The majority of the BLM's use of 2,4-D in terrestrial environments is for treatment of annual and perennial species. Under routine-use scenarios for 2,4-D for land application for control of annual/perennial species at the typical application rate of 1 lb a.e./acre, no exceedances of the USEPA's level of concern were identified for occupational or public receptors.

Table 6-1
Occupational Scenarios With Aggregate Risk Indices below One

Application Type	Application Vehicle	Application Method	Receptor	Typical Application Rate Scenario (a,b)			Maximum Application Rate Scenario (a,b)			Accidental Spill to Skin Scenario (a,b,c)
				Short-term	Intermediate-term	Long-term	Short-term	Intermediate-term	Long-term	Short-term (Dermal)
Aerial	Plane	Fixed Wing	Pilot	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (d) Rimsulfuron
Aerial	Plane	Fixed Wing	Mixer/Loader	2,4-D (S)	2,4-D (S)	2,4-D (AP) 2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (AP) 2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (AP) 2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (AP) 2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (d) Rimsulfuron
Aerial	Helicopter	Rotary	Pilot	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	2,4-D (d) Rimsulfuron
Aerial	Helicopter	Rotary	Mixer/Loader	*No ARI<1*	*No ARI<1*	2,4-D (S)	2,4-D (S)	2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (AP) 2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (d) Rimsulfuron
Ground	Human	Backpack	Applicator/Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	2,4-D (S)	2,4-D (AP) 2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (d) Rimsulfuron
Ground	Human	Horseback	Applicator/Mixer/Loader	2,4-D (S)	2,4-D (S)	2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (AP) 2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (AP) 2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (d) Rimsulfuron
Ground	ATV/UTV	Spot	Applicator	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	2,4-D (d) Rimsulfuron
Ground	ATV/UTV	Spot	Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (d) Rimsulfuron
Ground	ATV/UTV	Spot	Applicator/Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	2,4-D (d) Rimsulfuron
Ground	ATV/UTV	Boom/Broadcast	Applicator	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (d) Rimsulfuron
Ground	ATV/UTV	Boom/Broadcast	Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (d) Rimsulfuron
Ground	ATV/UTV	Boom/Broadcast	Applicator/Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (d) Rimsulfuron
Ground	Truck Mount	Spot	Applicator	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (d) Rimsulfuron
Ground	Truck Mount	Spot	Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (d) Rimsulfuron
Ground	Truck Mount	Spot	Applicator/Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	2,4-D (W) 2,4-D (FE) 2,4-D (S)	2,4-D (d) Rimsulfuron
Ground	Truck Mount	Boom/Broadcast	Applicator	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (d) Rimsulfuron
Ground	Truck Mount	Boom/Broadcast	Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (d) Rimsulfuron
Ground	Truck Mount	Boom/Broadcast	Applicator/Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (d) Rimsulfuron
Aquatic	Boat	Spot	Applicator	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	2,4-D (FE) 2,4-D (S)	2,4-D (d) Rimsulfuron
Aquatic	Boat	Spot	Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (d) Rimsulfuron
Aquatic	Boat	Spot	Applicator/Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	2,4-D (FE) 2,4-D (S)	2,4-D (d) Rimsulfuron
Aquatic	Boat	Boom/Broadcast	Applicator	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (d) Rimsulfuron
Aquatic	Boat	Boom/Broadcast	Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (d) Rimsulfuron
Aquatic	Boat	Boom/Broadcast	Applicator/Mixer/Loader	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (d) Rimsulfuron

ARI - Aggregate Risk Index.
ATV - All-Terrain Vehicle.
UTV - Utility Vehicle.
(a) - ARI values less than one indicate a level of concern.
(b) - Herbicides evaluated include: aminopyralid, clopyralid, 2,4-D, fluroxypyr, and rimsulfuron.
(c) - Concentrated Solution and Mixed Solutions (maximum application rate and typical application rate).
(d) - All formulations with the exception of the granulated formulation used to treat pond bottom.

2,4-D (AP) - 2,4-D (Land; Annual/Perennial Species)
2,4-D (W) - 2,4-D (Land; Woody Species)
2,4-D (FE) - 2,4-D (Aquatic; Floating and Emerged)
2,4-D (S) - 2,4-D (Aquatic; Submerged, Treatment of Volume of Water)

Table 6-2
Routine Public Scenarios/Receptors with Aggregate Risk Indices below One - Short-term Exposure

	Short-Term Routine Exposure Scenarios with Aggregate Risk Index below One (c,d)											
	Typical Application Rate Scenario						**Maximum Application Rate Scenario**					
AgDrift Scenario:	**Aerial**	**Aerial**	**Aerial**	**Aerial**	**Ground**	**Ground**	**Aerial**	**Aerial**	**Aerial**	**Aerial**	**Ground**	**Ground**
Land Type (a):	**Non-Forested**	**Non-Forested**	**Forested**	**Forested**	**Not Applicable**	**Not Applicable**	**Non-Forested**	**Non-Forested**	**Forested**	**Forested**	**Not Applicable**	**Not Applicable**
Equipment (b):	**Plane**	**Helicopter**	**Plane**	**Helicopter**	**Low Boom**	**High Boom**	**Plane**	**Helicopter**	**Plane**	**Helicopter**	**Low Boom**	**High Boom**
Hiker/Hunter (Adult)	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*
Berry Picker (Child)	2,4-D (S)	2,4-D (S)	2,4-D (W)	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (W) 2,4-D (S)	2,4-D (W) 2,4-D (S)	2,4-D (AP) 2,4-D (W)	*No ARI<1*	*No ARI<1*	2,4-D (W)
Berry Picker (Adult)	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	*No ARI<1*	2,4-D (W)	*No ARI<1*	*No ARI<1*	*No ARI<1*
Angler (Adult)	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*
Residential (Child)	2,4-D (S)	2,4-D (S)	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	2,4-D (S)	2,4-D (W)	*No ARI<1*	*No ARI<1*	*No ARI<1*
Residential (Adult)	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*
Native American (Child)	2,4-D (S)	2,4-D (S)	2,4-D (W)	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (W) 2,4-D (S)	2,4-D (W) 2,4-D (S)	2,4-D (AP) 2,4-D (W)	*No ARI<1*	*No ARI<1*	*No ARI<1*
Native American (Adult)	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S)	*No ARI<1*	2,4-D (W)	*No ARI<1*	*No ARI<1*	*No ARI<1*
Swimmer (Child)	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*
Swimmer (Adult)	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*	*No ARI<1*

ARI - Aggregate Risk Index.
(a) - Non-forested land type is used as a proxy for a pond for aerial scenarios. Ground scenarios are not differentiated in AgDRIFT by land type.
(b) - Low and High Boom applies to a truck mount or a boat mount boom.
(c) - Aggregate Risk Index values less than one indicate a level of concern.
(d) - Herbicides evaluated include: aminopyralid, clopyralid, 2,4-D, fluroxypyr, and rimsulfuron.

2,4-D (AP) - 2,4-D (Land; Annual/Perennial Species)
2,4-D (W) - 2,4-D (Land; Woody Species)
2,4-D (S) - 2,4-D (Aquatic, Submerged, Treatment of Volume of Water)

Table 6-3
Accidental Public Scenarios with Aggregate Risk Indices below One

Receptor	Accidental Exposure Scenarios with ARI below One (a,b)					Accidental Exposure Scenarios with ARI below One (a,b)						
	Dermal Contact Exposure Pathways					Dietary Exposure Pathways						
	Direct	Dermal	Swimming			Drinking Water Ingestion			Fish Ingestion			
	Spray of Receptor	Contact with Foliage	Spray of Waterbody	Helicopter Spill	Truck Spill	Spray of Waterbody (b)	Helicopter Spill	Truck Spill	Spray of Waterbody (b)	Helicopter Spill	Truck Spill	Berry Ingestion
Angler (Adult)	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (S) - M/T	--	--	--	2,4-D (S) - M/T 2,4-D (SB) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	*No ARI<1*	2,4-D (W) - M 2,4-D (FE) - M 2,4-D (S) - M/T	2,4-D (S) - M	--
Berry Picker (Adult)	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (W) - M 2,4-D (FE) - M 2,4-D (S) - M/T	--	--	--	2,4-D (S) - M/T 2,4-D (SB) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	--	--	--	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T
Berry Picker (Child)	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	--	--	--	2,4-D (W) - M 2,4-D (FE) - M 2,4-D (S) - M/T 2,4-D (SB) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	--	--	--	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T
Hiker/Hunter (Adult)	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (S) - M/T	--	--	--	2,4-D (S) - M/T 2,4-D (SB) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	--	--	--	--
Native American (Adult)	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (W) - M 2,4-D (FE) - M 2,4-D (S) - M/T	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S) - M 2,4-D (SB) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (S) - M 2,4-D (SB) - M	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T
Native American (Child)	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	*No ARI<1*	*No ARI<1*	*No ARI<1*	2,4-D (S) - M/T 2,4-D (SB) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (S) - M 2,4-D (SB) - M	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T
Residential (Adult)	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	--	--	--	--	--	--	--	--	--	--
Residential (Child)	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	--	--	--	--	--	--	--	--	--	--
Swimmer (Adult)	--	--	No ARI<1	2,4-D (W) - M 2,4-D (FE) - M 2,4-D (S) - M/T	2,4-D (S) - M	--	--	--	--	--	--	--
Swimmer (Child)	--	--	2,4-D (S) - M 2,4-D (SB) - M	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	2,4-D (AP) - M/T 2,4-D (W) - M/T 2,4-D (FE) - M/T 2,4-D (S) - M/T	--	--	--	--	--	--	--

ARI - Aggregate Risk Index.
M -Maximum Application Rate Scenario.
T - Typical Application Rate Scenario.
-- Receptor not exposed via this pathway.
(a) - ARI values less than one indicate a level of concern.
(b) - Herbicides evaluated include:
aminopyralid, clopyralid, 2,4-D, fluroxypyr, and rimsulfuron.

2,4-D (AP) - 2,4-D (Land; Annual/Perennial Species)
2,4-D (W) - 2,4-D (Land; Woody Species)
2,4-D (FE) - 2,4-D (Aquatic, Floating and Emerged)
2,4-D (S) - 2,4-D (Aquatic, Submerged, Treatment of Volume of Water)
2,4-D (SB) - 2,4-D (Aquatic, Submerged, Treatment of Pond Bottom)

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