

APPENDIX B

**Ecological Risk Assessment Worksheet –
Fluridone**

DERIVATION OF EECS

Section 3.0 of the Methods Document (ENSR 2005) presents the details of the exposure scenarios considered in the risk assessments. The following sub-sections describe the scenarios that were evaluated for bromacil. Note that in many cases, units were converted during the calculations (e.g., lb/acre converted to mg/cm²). These conversions were not included in the equations presented below.

Direct Spray

Plant and wildlife species may be unintentionally impacted during normal application of a terrestrial herbicide as a result of a direct spray of the receptor or the waterbody inhabited by the receptor, indirect contact with dislodgeable foliar residue after herbicide application, or consumption of prey items sprayed during application. These exposures may occur within the application area (consumption of prey items) or outside of the application area (waterbodies accidentally sprayed during application of terrestrial herbicide). Generally, impacts outside of the intended application area are accidental exposures and are not typical of BLM application practices. The following direct spray scenarios were evaluated:

Direct Spray of Terrestrial Wildlife

Small mammal or Insect 100% Dermal Absorption

$$\text{Surface Areas (A): cm}^2 = 12.3 \times \text{BW}^{0.65}$$

Where: BW = body weight in grams

$$\text{Amount deposited on } \frac{1}{2} \text{ receptor (Amnt): } 0.5 \times A \times R$$

Where: A = Surface area in cm²

R = Application rate in lb a.i./acre

Small mammal 1st order

$$\text{Proportion absorbed over period T (Prop): } 1 - \exp(-k T)$$

Where: k = First order dermal absorption rate (hour⁻¹)

T = Time (24 hours)

$$\text{Absorbed Dose: Amnt} \times \text{Prop} \div \text{BW}$$

Ingestion of Food Items Contaminated by Direct Spray

All herbivorous receptors ingestion acute

$$\text{Concentration on food (C): } R \times rr$$

Where: R = Application rate (lb a.i./acre)

rr = Residue rate as determined from Kenaga nomogram (mg/kg per lb/acre)

$$\text{Dose estimates (D): } C \times A \div \text{BW}$$

Where: C = Concentration on food (mg/kg food)

A = Wet weight food ingestion rate (kg/day)

BW = Body Weight

All herbivorous receptors ingestion chronic

$$\text{Initial concentration on food (C0): } R \times rr \times \text{Drift}$$

Where: R = Application rate (lb a.i./acre)

rr = Residue rate as determined from Kenaga nomogram (mg/kg per lb/acre)

Drift = 1

$$\text{Concentration on food at time T: } C0 \times \exp(-k \times T)$$

Where: C0 = Concentration on food at time zero (mg/kg food)

k = Decay Coefficient: $\ln(2) \div t50$ (days⁻¹)

T = Time (90 days)

$$\text{Time-weighted Average Concentration on vegetation (CTWA): } C0 \times (1 - \exp(-k \times T)) \div (k \times T)$$

$$\text{Dose estimates (D): } \text{CTWA} \times A \times \text{Prop} \div \text{BW}$$

Where: CTWA = Time Weighted Concentration on food (mg/kg food)

A = Wet weight food ingestion rate (kg/day)

Prop = Proportion of food impacted by direct spray (100%)

BW = Body Weight

Large carnivorous mammal ingestion acute

Amount deposited on small mammal prey (Amnt_mouse): $0.5 \times \text{SurfaceArea} \times R$

Where: $R = \text{Application rate (lb a.i./acre)}$

Dose estimates: $\text{Drift} \times \text{Prop} \times \text{Amnt_mouse} \div \text{BW_mouse} \times A \div \text{BW}$

Where: $\text{Drift} = 1$

$\text{Prop} = \text{Proportion of food impacted by direct spray (100\%)}$

$A = \text{Wet weight food ingestion rate (kg/day)}$

$\text{BW} = \text{Body Weight of carnivore}$

$\text{BW_mouse} = \text{Body weight of food (small mammal; mouse)}$

Large carnivorous mammal ingestion chronic

Initial concentration on mammal (C0): $0.5 \times \text{SurfaceArea} \times R \div \text{BW_smallmammal}$

Where: $R = \text{Application rate (lb a.i./acre)}$

$\text{SurfaceArea} = \text{Surface area of food (small mammal; mouse)}$

$\text{BW_smallmammal} = \text{Body weight of food (small mammal; mouse)}$

Concentration absorbed in small mammal at time T (C90): $C0 \times \exp(-k \times T)$

Where: $C0 = \text{Concentration on food at time zero (mg/kg food)}$

$k = \text{Decay Coefficient: } \ln(2)/t_{50} \text{ (days}^{-1}\text{)}$

$T = \text{Time (90 days)}$

Dose estimates: $C90 \times \text{FIR_coyote} \times \text{Prop} \div \text{BW}$

Where: $C90 = \text{Concentration of herbicide in food at 90 days}$

$\text{FIR} = \text{Wet weight food ingestion rate (mg/kg-day)}$

$\text{Prop} = \text{Proportion of food impacted by direct spray (100\%)}$

$\text{BW} = \text{Body Weight}$

Accidental Direct Spray Over Pond

Mass in Pond (Mp): $A_p \times R$

Where: $A_p = \text{Area of pond}$

$R = \text{Application rate (lb a.i./acre)}$

Concentration in Pond: $M_p \div (V_p)$

Where: $V_p = \text{Volume of pond}$

Accidental Direct Spray Over Stream

Mass in Stream Reach (Ms): $A_s \times R$

Where: $A_s = \text{Area of stream affected by spray}$

$R = \text{Application rate (lb a.i./acre)}$

Concentration in Pond: $M_s \div (V_s)$

Where: $V_s = \text{Volume of stream reach affected by spray}$

Accidental Spill to Pond

To represent worst-case potential impacts to ponds, a spill scenario was considered. A truck or helicopter spilling an entire load of herbicide mixed for the maximum application rate into a 1/4 acre, 1 meter deep pond.

Truck or Helicopter Spill into Pond

Concentrations in water (Cw): $C_m \times V_{\text{spill}} \div V_p$

Where: $C_m = \text{Herbicide concentration in the truck or helicopter mixture (mg a.i./L)}$

$V_{\text{spill}} = \text{Volume of the spill (L)}$

$V_p = \text{Volume of the pond (L)}$

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General note: Exposure parameters and equations in the following tables are described in more detail in the *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Methodology* (ENSR 2005) and Section 4 of the ecological risk assessment for this herbicide.

TABLE B-1

Direct Spray of Terrestrial Receptors and Exposure from Indirect Contact With Foliage

Parameter		Pollinating Insect	Small Mammal	Units
Duration of exposure (T)		24	24	hours
Body weight (BW)		0.000093	0.02	kg
Surface areas (A): $cm^2 = 12.3 \times BW(g)^{0.65}$ ¹		2.63	86.21	cm^2
Application rates (R)	Typical	0.15	0.15	lb/acre
	Maximum	1.3	1.3	lb/acre
Amount deposited on 1/2 receptor (Amnt): $0.5 \times A \times R \times cf$ ²	Typical	0.0022	0.0725	mg
	Maximum	0.0192	0.6281	mg
Dose Estimate Assuming 100% Dermal Adsorption³				
Absorbed Dose: $Amnt \times Prop / BW$	Typical	2.38E+01	3.62E+00	mg/kg bw
	Maximum	2.06E+02	3.14E+01	mg/kg bw
Dose Estimate Assuming First Order Dermal Adsorption⁴				
First-order dermal absorption coefficient (k)	Central estimate (ka)	0.0019	0.0019	hour ⁻¹
Proportion absorbed over period T (Prop): $1 - \exp(-k \times T)$ ⁵	Typical	0.0284	0.0284	unitless
	Maximum	0.0284	0.0284	unitless
Absorbed dose: $Amnt \times Prop / BW$	Typical	6.75E-01	1.03E-01	mg/kg bw
	Maximum	5.85E+00	8.92E-01	mg/kg bw

RISK QUOTIENTS - Direct Spray ⁶	Toxicity Reference Value (mg/kg bw) ⁷	Typical Application	Maximum Application
Small mammal - 100% absorption	20,453	1.95E-04	1.69E-03
Pollinating insect - 100% absorption	11,699	2.03E-03	1.76E-02
Small mammal - 1st order dermal adsorption	20,453	5.54E-06	4.80E-05

RISK QUOTIENTS - Indirect Contact ⁸	Toxicity Reference Value (mg/kg bw) ⁷	Typical Application	Maximum Application
Small mammal - 100% absorption	20,453	1.95E-05	1.69E-04
Pollinating insect - 100% absorption	11,699	2.03E-04	1.76E-03
Small mammal - 1st order dermal adsorption	20,453	5.54E-07	4.80E-06

¹Surface area calculation for mammals from Stahl (1967; presented in USEPA 1993). No surface area calculation identified for insects. Mammalian equation used as a surrogate.

²A conversion factor (cf) of 0.011208493 was used to convert the application rate (R) from lb/acre to mg/cm².

³100% dermal absorption - all of the herbicide falling on the receptor was assumed to penetrate the skin within 24 hours.

⁴1st order dermal absorption - absorption occurs over 24 hours, taking into consideration the potential for some herbicide to not be absorbed.

⁵ $\exp(-k \times T) = e^{-(k \times T)}$, where e is a constant = 2.7828.

⁶Risk Quotient = Estimated Dose/Toxicity Reference Value.

⁷Toxicity Reference Value (TRV) - TRVs relate the dose of a compound with a potentially adverse effect. TRVs were selected during a review of the ecotoxicological literature.

⁸Exposure from indirect contact assumed to be 1/10 of direct spray exposure (Harris and Solomon 1992).

TABLE B-2

Potential Risks to Small Herbivorous/Omnivorous Mammal (Deer Mouse) From Consumption of Contaminated Fruit – (Acute Exposure Scenario)

Parameters/Assumptions		Value	Units
Body weight (BW)		0.02	kg
Food ingestion rate (dry weight [dw]) ¹		0.003364	kg dw/day
Food ingestion rate (wet weight [ww]) (ir) ²		0.01463	kg ww/day
Application rates (R)	Typical	0.15	lb/acre
	Maximum	1.3	lb/acre
Residue rate – berries (rr) ³	Typical	5.4	mg/kg per lb/acre
	Maximum	40.7	mg/kg per lb/acre
Concentration on berries (C): R × rr	Typical	0.81	mg/kg fruit
	Maximum	52.91	mg/kg fruit
Dose estimates (D): C × ir / BW	Typical	5.92E-01	mg/kg bw
	Maximum	3.87E+01	mg/kg bw

RISK QUOTIENTS ⁴ - Ingestion	Toxicity Reference Value (mg/kg bw) ⁵	Typical Application	Maximum Application
Small mammalian herbivore/omnivore – (acute exposure)	20,453	2.90E-05	1.89E-03

¹Calculated using algorithm developed by Nagy (1987) for rodents; where food ingestion rate (g dw/day) = 0.621 × (BW g)^{0.564}; converted into kg dw/day.

²Assumes fruit is 77% water (USEPA 1993; Table 4-2 - value for fruit pulp and skin).

³Residue rates were obtained from the Kenaga nomogram as updated (Fletcher et al., 1994) and are vegetation-specific.

⁴Risk Quotient = Estimated Dose/Toxicity Reference Value (TRV).

⁵Toxicity Reference Value (TRV) - TRVs relate the dose of a compound with a potentially adverse effect. TRVs were selected during a review of the ecotoxicological literature.

TABLE B-3

Potential Risks to Small Herbivorous/Omnivorous Mammal (Deer Mouse) From Consumption of Contaminated Fruit – (Chronic Exposure Scenario)

Parameters/Assumptions		Value	Units
Duration of exposure (T)		90	days
Body weight (BW)		0.02	kg
Food ingestion rate (dry weight [dw]) ¹		0.0034	kg dw/day
Food ingestion rate (wet weight [ww]) (ir) ²		0.0146	kg ww/day
Half life on vegetation (t ₅₀)	Herbicide specific	365	days
Application rates (R)	Typical	0.15	lb/acre
	Maximum	1.3	lb/acre
Residue rate - berries (rr) ³	Typical	5.4	mg/kg per lb/acre
	Maximum	40.7	mg/kg per lb/acre
Drift (Drift)	Typical	1	unitless
	Maximum	1	unitless
Decay coefficient (k): ln(2) / t ₅₀ ⁴	Typical	0.0019	days ⁻¹
	Maximum	0.0019	days ⁻¹
Initial concentration on berries (C ₀): R × rr × Drift	Typical	0.81	mg/kg fruit
	Maximum	52.91	mg/kg fruit
Concentration on berries at time T: C ₀ × exp(-k×T) ⁵	Typical	0.6827	mg/kg fruit
	Maximum	44.5976	mg/kg fruit
Time-weighted average concentration on vegetation (CTWA): C ₀ × (1-exp(-k×T)) / (k×T) ⁵	Typical	0.7446	mg/kg fruit
	Maximum	48.6355	mg/kg fruit
Proportion of diet contaminated (PC)	Typical	1	unitless
	Maximum	1	unitless
Dose estimates (D): (CTWA × ir × PC) / BW	Typical	5.45E-01	mg/kg bw/day
	Maximum	3.56E+01	mg/kg bw/day

RISK QUOTIENTS ⁶ - Ingestion	Toxicity Reference Value (mg/kg bw/day) ⁷	Typical Application	Maximum Application
Small mammalian herbivore/omnivore – (chronic exposure)	16	3.40E-02	2.22E+00

¹Calculated using algorithm developed by Nagy (1987) for rodents; where food ingestion rate (g dw/day) = 0.621×(BW g)^{0.564}; converted into kg dw/day.
²Assumes fruit is 77% water (USEPA 1993; Table 4-2 - value for fruit pulp and skin).
³Residue rates were obtained from the Kenaga nomogram as updated (Fletcher et al., 1994) and are vegetation-specific.
⁴ln = Natural log function.
⁵exp(-k×T) = e^(-k×T), where e is a constant = 2.7828.
⁶Risk Quotient = Estimated Dose/Toxicity Reference Value.
⁷Toxicity Reference Value (TRV) - TRVs relate the dose of a compound with a potentially adverse effect. TRVs were selected during a review of the ecotoxicological literature.

TABLE B-4

Potential Risks to Large Herbivorous Mammal (Mule Deer) from Consumption of Contaminated Vegetation – (Acute Exposure Scenario)

Parameters/Assumptions		Value	Units
Body weight (BW)		70	kg
Food ingestion rate (dry weight [dw]) ¹		1.9212	kg dw/day
Food ingestion rate (wet weight [ww]) (ir) ²		6.4038	kg ww/day
Duration of exposure (D)		1	day
Application rates (R)	Typical	0.15	lb/acre
	Maximum	1.3	lb/acre
Residue rate - grass (rr) ³	Typical	36	mg/kg per lb/acre
	Maximum	197	mg/kg per lb/acre
Concentration on grass (C): R × rr	Typical	5.4	mg/kg grass
	Maximum	256.1	mg/kg grass
Drift (Drift)	Typical	1	unitless
	Maximum	1	unitless
Proportion of diet contaminated (PC)	Typical	1	unitless
	Maximum	1	unitless
Dose estimates (D): (Drift × PC × C × ir) / BW	Typical	4.94E-01	mg/kg bw/day
	Maximum	2.34E+01	mg/kg bw/day

RISK QUOTIENTS ⁴ – Ingestion	Toxicity Reference Value (mg/kg bw/day) ⁵	Typical Application	Maximum Application
Large mammalian herbivore/gramivore (acute exposure)	2,659	1.86E-04	8.81E-03

¹Calculated using algorithm developed by Nagy (1987) for herbivores; where food ingestion rate (g dw/day) = 0.577×(BW g)^{0.727}; converted into kg dw/day.

²Assumes grass is 70% water (USEPA 1993; Table 4-2 - lowest value for young grasses).

³Residue rates were obtained from the Kenaga nomogram as updated (Fletcher et al., 1994) and are vegetation-specific.

⁴Risk Quotient = Estimated Dose/Toxicity Reference Value.

⁵Toxicity Reference Value (TRV) - TRVs relate the dose of a compound with a potentially adverse effect. TRVs were selected during a review of the ecotoxicological literature.

TABLE B-5

Potential Risks to Large Herbivorous Mammal (Mule Deer) From Consumption of Contaminated Vegetation – (Chronic Exposure Scenario)

Parameters/Assumptions		Value	Units
Duration of exposure (T)		90	day
Body weight (BW)		70	kg
Food ingestion rate (dry weight [dw]) ¹		1.9212	kg dw/day
Food ingestion rate (wet weight [ww]) (ir) ²		6.4038	kg ww/day
Half life on vegetation (t ₅₀)	Herbicide specific	365	days
Application rates (R)	Typical	0.15	lb/acre
	Maximum	1.3	lb/acre
Residue rate - grass (rr) ³	Typical	36	mg/kg per lb/acre
	Maximum	197	mg/kg per lb/acre
Drift (Drift)	Typical	1	unitless
	Maximum	1	unitless
Decay coefficient (k): ln(2) / t ₅₀ ⁴	Typical	0.0019	days ⁻¹
	Maximum	0.0019	days ⁻¹
Initial concentration on grass (C ₀): R × rr × Drift	Typical	5.4	mg/kg grass
	Maximum	256.1	mg/kg grass
Concentration on grass at time T: C ₀ × exp(-k×T) ⁵	Typical	4.5516	mg/kg grass
	Maximum	215.8654	mg/kg grass
Time-weighted average concentration on vegetation (CTWA): C ₀ × (1-exp(-k×T)) / (k×T) ⁵	Typical	4.9637	mg/kg vegetation
	Maximum	235.4099	mg/kg vegetation
Proportion of diet contaminated (PC)	Typical	1	unitless
	Maximum	1	unitless
Dose estimates (D): (CTWA × ir × PC) / BW	Typical	4.54E-01	mg/kg bw/day
	Maximum	2.15E+01	mg/kg bw/day

RISK QUOTIENTS ⁶ – Ingestion	Toxicity Reference Value (mg/kg bw/day) ⁷	Typical Application	Maximum Application
Large mammalian herbivore/gramivore – (chronic exposure)	49	9.27E-03	4.40E-01

¹Calculated using algorithm developed by Nagy (1987) for herbivores; where food ingestion rate (g dw/day) = 0.577×(BW g)^{0.727}; converted into kg dw/day.

²Assumes grass is 70% water (USEPA 1993; Table 4-2 - lowest value for young grasses).

³Residue rates were obtained from the Kenaga nomogram as updated (Fletcher et al., 1994) and are vegetation-specific.

⁴ln = Natural log function.

⁵exp(-k×T) = e^{-k×T}, where e is a constant = 2.7828.

⁶Risk Quotient = Estimated Dose/Toxicity Reference Value.

⁷Toxicity Reference Value (TRV) - TRVs relate the dose of a compound with a potentially adverse effect. TRVs were selected during a review of the ecotoxicological literature.

TABLE B-6

Potential Risks to Carnivorous Mammal (Coyote) From Consumption of Contaminated Small Mammals – (Acute Exposure Scenario)

Parameters/Assumptions		Value	Units
Body weight (BW)		12	kg
Body weight small mammal (BW_mouse)		0.02	kg
Surface area small mammal (A)		86.21	cm ²
Food ingestion rate (dry weight [dw]) ¹		0.5297	kg dw/day
Food ingestion rate (wet weight [ww]) (ir) ²		1.6554	kg ww/day
Duration of exposure (D)		1	day
Application rates (R)	Typical	0.15	lb/acre
	Maximum	1.3	lb/acre
Amount deposited on small mammal prey (Amnt_mouse): $0.5 \times A \times R$ ³	Typical	0.0725	mg
	Maximum	0.6281	mg
Drift (Drift)	Typical	1	unitless
	Maximum	1	unitless
Proportion of diet contaminated (PC)	Typical	1	unitless
	Maximum	1	unitless
Dose estimates (D) : $[(\text{Drift} \times \text{PC} \times \text{Amnt_mouse}) / \text{BW_mouse}] \times \text{ir} / \text{BW}$	Typical	5.00E-01	mg/kg bw
	Maximum	4.33E+00	mg/kg bw

RISK QUOTIENTS ⁴ - Ingestion	Toxicity Reference Value (mg/kg bw) ⁵	Typical Application	Maximum Application
Large carnivorous mammal (acute exposure)	4,133	1.21E-04	1.05E-03

¹Calculated using algorithm developed by Nagy (1987); where food ingestion rate (g dw/day) = 0.0687×(BW g)^{0.822}; converted into kg dw/day.

²Assumes mammals are 68% water (USEPA 1993).

³Surface area (A) and body weight of mouse receptor presented in Table B-1. Surface area calculation for mammals from Stahl (1967; presented in USEPA 1993).

⁴Risk Quotient = Estimated Dose/Toxicity Reference Value.

⁵Toxicity Reference Value (TRV) - TRVs relate the dose of a compound with a potentially adverse effect. TRVs were selected during a review of the ecotoxicological literature.

TABLE B-7

Potential Risks to Carnivorous Mammal (Coyote) From Consumption of Contaminated Small Mammals – (Chronic Exposure Scenario)

Parameters/Assumptions		Value	Units
Duration of exposure (T)		90	day
Body weight (BW)		12	kg
Body weight small mammal (BW_mouse)		0.02	kg
Surface area small mammal (A)		86.21	cm ²
Food ingestion rate (dry weight [dw]) ¹		0.5297	kg dw/day
Food ingestion rate (wet weight, [ww]) (ir) ²		1.6554	kg ww/day
Application rates (R)	Typical	0.15	lb/acre
	Maximum	1.3	lb/acre
Drift (Drift)	Typical	1	unitless
	Maximum	1	unitless
Decay coefficient (k): $\ln(2) / t_{50}$ ³	Typical	0.0019	days ⁻¹
	Maximum	0.0019	days ⁻¹
Initial concentration on mammal (C ₀): $(0.5 \times A \times R) / BW_mouse$	Typical	3.6236	mg/kg mammal
	Maximum	31.4042	mg/kg mammal
Concentration absorbed in small mammal at time T (C ₉₀): $C_0 \times \exp(-k \times T)$ ⁴	Typical	0.1029	mg/kg mammal
	Maximum	0.8915	mg/kg mammal
Proportion of diet contaminated (PC)	Typical	1	unitless
	Maximum	1	unitless
Dose estimates: $(C_{90} \times ir \times PC) / BW$	Typical	1.42E-02	mg/kg bw/day
	Maximum	1.23E-01	mg/kg bw/day

RISK QUOTIENTS ⁵ – Ingestion	Toxicity Reference Value (mg/kg bw/day) ⁶	Typical Application	Maximum Application
Large mammalian carnivore – (chronic exposure)	76	1.87E-04	1.62E-03

¹Calculated using algorithm developed by Nagy (1987); where food ingestion rate (g dw/day) = 0.0687×(BW g)^{0.822}; converted into kg dw/day.
²Assumes mammals are 68% water (USEPA 1993).
³ln = Natural log function.
⁴exp(-k×T) = e^{-k×T}, where e is a constant = 2.7828.
⁵Risk Quotient = Estimated Dose/Toxicity Reference Value.
⁶Toxicity Reference Value (TRV) - TRVs relate the dose of a compound with a potentially adverse effect. TRVs were selected during a review of the ecotoxicological literature.

TABLE B-8

Potential Risks to Insectivorous Bird (American Robin) From Consumption of Contaminated Insects – (Acute Exposure Scenario)

Parameters/Assumptions		Value	Units
Body weight (BW)		0.08	kg
Food ingestion rate (dry weight [dw]) ¹		0.0112	kg dw/day
Food ingestion rate (wet weight [ww]) (ir) ²		0.0363	kg ww/day
Duration of exposure (D)		1	day
Application rates (R)	Typical	0.15	lb/acre
	Maximum	1.3	lb/acre
Residue rate - insects (rr) ³	Typical	45	mg/kg per lb/acre
	Maximum	350	mg/kg per lb/acre
Concentration on insects (C): R × rr	Typical	6.75	mg/kg insect
	Maximum	455	mg/kg insect
Drift (Drift)	Typical	1	unitless
	Maximum	1	unitless
Proportion of diet contaminated (PC)	Typical	1	unitless
	Maximum	1	unitless
Dose estimates: (Drift × PC × C × ir) / BW	Typical	3.06E+00	mg/kg bw
	Maximum	2.06E+02	mg/kg bw

RISK QUOTIENTS ⁴ – Ingestion	Toxicity Reference Value (mg/kg bw) ⁵	Typical Application	Maximum Application
Small insectivorous bird – (acute exposure)	13,135	2.33E-04	1.57E-02

¹Calculated using algorithm developed by Nagy (1987) for all birds; where food ingestion rate (kg dw/day) = 0.0582×(BW)^{0.651}.
²Assumes insects are 69% water (USEPA 1993; Table 4-1 - value for grasshoppers and crickets).
³Residue rates were obtained from the Kenaga nomogram as updated (Fletcher et al., 1994).
⁴Risk Quotient = Estimated Dose/Toxicity Reference Value.
⁵Toxicity Reference Value (TRV) - TRVs relate the dose of a compound with a potentially adverse effect. TRVs were selected during a review of the ecotoxicological literature.

TABLE B-9

Potential Risks to Insectivorous Bird (American Robin) From Consumption of Contaminated Insects – (Chronic Exposure Scenario)

Parameters/Assumptions		Value	Units
Duration of exposure (T)		90	day
Body weight (BW)		0.08	kg
Food ingestion rate (dry weight [dw]) ¹		0.0112	kg dw/day
Food ingestion rate (wet weight [ww]) (ir) ²		0.0363	kg ww/day
Half life on insect (t ₅₀)	Herbicide specific	365	days
Application rates (R)	Typical	0.15	lb/acre
	Maximum	1.3	lb/acre
Residue rate - insects (rr) ³	Typical	45	mg/kg per lb/acre
	Maximum	350	mg/kg per lb/acre
Drift (Drift)	Typical	1	unitless
	Maximum	1	unitless
Decay coefficient (k): ln(2) / t ₅₀ ⁴	Typical	0.0019	days ⁻¹
	Maximum	0.0019	days ⁻¹
Initial concentration on insects (C ₀): R × rr × Drift	Typical	6.75	mg/kg insect
	Maximum	455	mg/kg insect
Concentration on insects at time T (C ₉₀): C ₀ × exp(-k×T) ⁵	Typical	5.6895	mg/kg insect
	Maximum	383.5172	mg/kg insect
Time-weighted average concentration on insects (CTWA): C ₀ × (1-exp(-k×T)) / (k×T) ⁵	Typical	6.2047	mg/kg insect
	Maximum	418.2410	mg/kg insect
Proportion of diet contaminated (PC)	Typical	1	unitless
	Maximum	1	unitless
Dose estimates (D): (CTWA × ir × PC) / BW	Typical	2.81E+00	mg/kg bw/day
	Maximum	1.90E+02	mg/kg bw/day

RISK QUOTIENTS ⁶ – Ingestion	Toxicity Reference Value (mg/kg bw/day) ⁷	Typical Application	Maximum Application
Small insectivorous bird – (chronic exposure)	604	4.66E-03	3.14E-01

¹Calculated using algorithm developed by Nagy (1987) for all birds; where food ingestion rate (kg dw/day) = 0.0582×(BW)^{0.651}.
²Assumes insects are 69% water (USEPA 1993; Table 4-1 - value for grasshoppers and crickets).
³Residue rates were obtained from the Kenaga nomogram as updated (Fletcher et al., 1994).
⁴ln = Natural log function.
⁵exp(-k×T) = e^{-k×T}, where e is a constant = 2.7828.
⁶Risk Quotient = Estimated Dose/Toxicity Reference Value.
⁷Toxicity Reference Value (TRV) - TRVs relate the dose of a compound with a potentially adverse effect. TRVs were selected during a review of the ecotoxicological literature.

TABLE B-10

Potential Risks to Herbivorous Bird (Canada goose) From Consumption of Contaminated Vegetation – (Acute Exposure Scenario)

Parameters/Assumptions		Value	Units
Body weight (BW)		3.72	kg
Food ingestion rate (dry weight [dw]) ¹		0.1368	kg dw/day
Food ingestion rate (wet weight [ww]) (ir) ²		0.9125	kg ww/day
Duration of exposure (D)		1	day
Application rates (R)	Typical	0.15	lb/acre
	Maximum	1.3	lb/acre
Residue rate - vegetation (rr) ³	Typical	5.25	mg/kg per lb/acre
	Maximum	384.8	mg/kg per lb/acre
Concentration on vegetation (C): R × rr	Typical	1	mg/kg veg
	Maximum	1	mg/kg veg
Drift (Drift)	Typical	1	unitless
	Maximum	1	unitless
Proportion of diet contaminated (PC)	Typical	1.29E+00	unitless
	Maximum	9.44E+01	unitless
Dose estimates: (Drift × PC × C × ir) / BW	Typical	5.25	mg/kg bw
	Maximum	384.8	mg/kg bw

RISK QUOTIENTS ⁴ - Ingestion	Toxicity Reference Value (mg/kg bw) ⁵	Typical Application	Maximum Application
Large herbivorous bird – (acute exposure)	2270	5.67E-04	4.16E-02

¹Calculated using algorithm developed by Nagy (1987) for all birds; where food ingestion rate (kg dw/day) = 0.0582×(BW)^{0.651}.
²Assumes vegetation is 85% water (USEPA 1993; Table 4-2 - value for dicotyledons).
³Residue rates were obtained from the Kenaga nomogram as updated (Fletcher et al., 1994) and are vegetation-specific.
⁴Risk Quotient = Estimated Dose/Toxicity Reference Value.
⁵Toxicity Reference Value (TRV) - TRVs relate the dose of a compound with a potentially adverse effect. TRVs were selected during a review of the ecotoxicological literature.

TABLE B-11

Potential Risks to Herbivorous Bird (Canada goose) From Consumption of Contaminated Vegetation – (Chronic Exposure Scenario)

Parameters/Assumptions		Value	Units
Duration of exposure (T)		90	day
Body weight (BW)		3.72	kg
Food ingestion rate (dry weight [dw]) ¹		0.1369	kg dw/day
Food ingestion rate (wet weight [ww]) (ir) ²		0.9126	kg ww/day
Half life on vegetation (t ₅₀)	Herbicide specific	365	days
Application rates (R)	Typical	0.15	lb/acre
	Maximum	1.3	lb/acre
Residue rate - vegetation (rr) ³	Typical	35	mg/kg per lb/acre
	Maximum	296	mg/kg per lb/acre
Drift (Drift)	Typical	1	unitless
	Maximum	1	unitless
Decay coefficient (k): ln(2) / t ₅₀ ⁴	Typical	0.0019	days ⁻¹
	Maximum	0.0019	days ⁻¹
Initial concentration on vegetation (C ₀): R × rr × Drift	Typical	5.25	mg/kg veg
	Maximum	384.8	mg/kg veg
Concentration on vegetation at time T (C ₉₀): C ₀ × exp(-k×T) ⁵	Typical	4.4252	mg/kg veg
	Maximum	324.3460	mg/kg veg
Time-weighted Average Concentration on vegetation (CTWA): C ₀ × (1-exp(-k×T))/(k×T) ⁵	Typical	4.8259	mg/kg veg
	Maximum	353.7124	mg/kg veg
Proportion of diet contaminated (PC)	Typical	1	unitless
	Maximum	1	unitless
Dose estimates (D): (CTWA × ir × PC) / BW	Typical	1.18E+00	mg/kg bw/day
	Maximum	8.68E+01	mg/kg bw/day

RISK QUOTIENTS ⁶ - Ingestion	Toxicity Reference Value (mg/kg bw/day) ⁷	Typical Application	Maximum Application
Large herbivorous bird (chronic exposure)	100	1.18E-02	8.68E-01

¹Calculated using algorithm developed by Nagy (1987) for all birds; where food ingestion rate (kg dw/day) = 0.0582×(BW)^{0.651}.
²Assumes vegetation is 85% water (USEPA 1993; Table 4-2 - value for dicotyledons).
³Residue rates were obtained from the Kenaga nomogram as updated (Fletcher et al., 1994) and are vegetation-specific.
⁴ln = Natural log function.
⁵exp(-k×T) = e^{^(-k×T)}, where e is a constant = 2.7828.
⁶Risk Quotient = Estimated Dose/Toxicity Reference Value.
⁷Toxicity Reference Value (TRV) - TRVs relate the dose of a compound with a potentially adverse effect. TRVs were selected during a review of the ecotoxicological literature.

TABLE B-12

Potential Risk to Predatory Bird from Consumption of Contaminated Fish from Pond – (Pond Impacted by Regular Application of Herbicide)

Parameters/ Assumptions		Value	Units
Body weight (W)		5.15	kg
Food ingestion rate (dry weight [dw]) ¹		1.02E-01	kg dw/day
Food ingestion rate (wet weight [ww]) (ir) ²		4.07E-01	kg ww/day
Bioconcentration factor (BCF)		3.01	L/kg fish
Food Chain Multiplier Trophic Level 2 (FCM_TL2)		1	unitless
Food Chain Multiplier Trophic Level 3 (FCM_TL3)		1	unitless
Proportion of diet contaminated (PC)		1	unitless
Toxicity reference value (TRV)		100	mg/kg-bw/day
Concentration in fish ³	Typical	5.06E-02	mg/kg bw fish
(C _{fish}) : Pond_conc × BCF × FCM_TL2 × FCM_TL3	Maximum	4.39E-01	mg/kg bw fish
Dose estimate (D) : (C _{fish} × ir × PC) / BW	Typical	4.00E-03	mg/kg bw fish
	Maximum	3.47E-02	mg/kg bw fish

RISK QUOTIENTS – Ingestion ⁴	Toxicity Reference Value ⁵	Typical Application	Maximum Application
Piscivorous bird – (chronic exposure)	100	4.00E-05	3.47E-04

¹Calculated using algorithm developed by Nagy (1987) for all birds; where Food Ingestion Rate (kg dw/day) = 0.0582*(BW)^{0.651}.
²Assumes fish are 75% water (USEPA 1993; Table 4-2 - value for dicotyledons).
³Pond concentrations presented in Table B-15.
⁴Risk Quotient = Estimated Dose/Toxicity Reference Value.
⁵Toxicity Reference Value (TRV) - TRVs relate the dose of a compound with a potentially adverse effect. TRVs were selected during a review of the ecotoxicological literature.

TABLE B-13

Potential Risks to Non-target Terrestrial Plants from Direct Spray and Spray Drift

DIRECT SPRAY	Terrestrial Concentration (lb/acre)	Typical Species RQ¹	Rare, Threatened, and Endangered Species RQ¹
Typical application rate	0.15	NA	NA
Maximum application rate	1.3	NA	NA

¹Risk Quotient = Estimated Dose/Toxicity Reference Value.

TABLE B-14

Potential Risks to Aquatic Species from Accidental Spill to Pond – (Acute Exposure)

Parameters/Assumptions	Value	Units
Volume of pond (Vp)	1,011,715	L
Volume of spill		
Truck (Vspill _t)	757	L
Helicopter(Vspill _h)	529.9	L
Herbicide concentration (Cm)¹		
Truck mixture (Cm _t)	6,232	mg/L
Helicopter mixture (Cm _h)	31,158	mg/L

Scenario	Concentrations in water (Cw): Cm × Vspill / Vp	Units	Risk Quotients ²		
			Fish	Aquatic Invertebrates	Non-Target Aquatic Plants
Truck spill into pond	4.66	mg/L	1.10E+00	3.59E+00	1.55E+00
Helicopter spill into pond	16.32	mg/L	3.84E+00	1.26E+01	5.44E+00

¹Based on herbicide mixed for the maximum application rate, where truck spray rate is 25 gallons per acre and helicopter spray rate is 5 gallons per acre. Cm = [application rate x (1/spray rate)] converted from lb/gallon to mg/L.
²Risk Quotient = Estimated Dose/Toxicity Reference Value.

TABLE B-15

Potential Risk to Aquatic Species from Direct Spray of Pond and Stream – (Acute Exposure)

Parameters/Assumptions		Value	Units
Pond			
Application rates (R)	Typical	0.15	lb/acre
	Maximum	1.3	lb/acre
Area of pond (Area)		0.25	acre
Volume of pond (Vol)		1,011,715	L
Mass sprayed on pond (R x Area)	Typical	17,009.7	mg
	Maximum	147,417.4	mg
Concentration in pond water (Mass/Volume)	Typical	0.0168	mg/L
	Maximum	0.1457	mg/L
Stream			
Width of stream		2	m
Length of stream impacted by direct spray		636.15	m
Area of stream impacted by spray (Area)		1,272.3	m ²
Depth of stream		0.2	m
Instantaneous volume of stream impacted by direct spray (Vol)		254,460	L
Mass sprayed on stream (R x Area)	Typical	0.047	lb
	Maximum	0.409	lb
Mass sprayed on stream - converted to mg	Typical	21,391.059	mg
	Maximum	185,389.178	mg
Concentration in stream water (Mass/Vol)	Typical	0.0841	mg/L
	Maximum	0.7286	mg/L

Scenario	Concentration in water (mg/L)	Risk Quotients ¹		
		Fish	Aquatic Invertebrates	Non-Target Aquatic Plants
Acute				
Direct spray to pond - Normal Application				
Typical application	1.68E-02	3.96E-03	1.29E-02	5.60E-03
Maximum application	1.46E-01	3.43E-02	1.12E-01	4.86E-02
Direct spray to stream - Accidental Spray				
Typical application	8.41E-02	1.98E-02	6.47E-02	2.80E-02
Maximum application	7.29E-01	1.71E-01	5.60E-01	2.43E-01
Chronic				
Direct spray to pond - Normal Application				
Typical application	1.68E-02	3.36E-02	2.80E-02	1.68E-02
Maximum application	1.46E-01	2.91E-01	2.43E-01	1.46E-01
Direct spray to stream - Accidental Spray				
Typical application	8.41E-02	1.68E-01	1.40E-01	8.41E-02
Maximum application	7.29E-01	1.46E+00	1.21E+00	7.29E-01

¹Risk Quotient = Estimated Dose/Toxicity Reference Value.

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