



**Hexachlorobenzene as an Impurity
in Clopyralid -
WordPerfect Worksheets for Human Health
Risk Assessment**

Worksheet Version 2.04

Prepared for:



**USDA, Forest Service
Forest Health Protection**



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GENERAL NOTES

The worksheets included in this document are based on Worksheet Version 2.04. See SERA WSD 01-2.04, Documentation for Worksheets Version 2.04 - Human Health and Ecological Risk Assessments, dated February 25, 2003.

These worksheets are arranged in the following order:

	Table of Contents
Series A	General values and models
Series B	Chemical specific data
Series C	Worker exposures
Series D	General public exposures
Series E	HHRA Summary Tables
	List of general references

Most worksheets are designated by a simple alphanumeric code. For example, Worksheet D03 is the third worksheet in Series D. Some closely related worksheets are designated by an additional alphabetic sub-code. For example, Worksheets D01a and D01b are the direct spray scenarios for a child and a woman, respectively.

The worksheets in Series A and B also have short descriptive synonyms, as indicated in the table of contents. For example, Worksheet A03 contains the general assumptions used in exposure assessments for the general public and is designated as *PUBL*.

The WordPerfect worksheets contain a much more detailed set of Series A and B worksheets than do the EXCEL worksheets. As noted in the documentation, the primary use of the EXCEL worksheets at this stage is to check rather than replace the WordPerfect worksheets. As the worksheets develop further, additional functionality will probably be added to the EXCEL worksheets to make them easier to manipulate and maintain.

It should be noted that all estimates of drift for chronic exposures for the off-site consumption of contaminated vegetation (Worksheets F04b, F11b, and F13b) all based on low-boom ground applications. These will need to be changed for high-boom or air-blast applications. For aerial applications, estimates specific to the program should be based on AGDRIFT.

CHEMICAL SPECIFIC NOTES

Information in these worksheets is taken from SERA TR 02-43-17-03a, Clopyralid - Human Health and Ecological Risk Assessment, Peer Review Draft, dated August 29, 2003. All section numbers cited in these worksheets refer to this report.

NON-STANDARD WORKSHEETS

Worksheet B01 is modified to calculate the functional application rate of hexachlorobenzene base on the standard application for clopyralid and the concentration of hexachlorobenzene in clopyralid. No ranges are used. Worksheet B02 is modified to include the cancer potency parameter for hexachlorobenzene as well as an accumulation factor from soil for plants.

The worksheets for the consumption of contaminated vegetation (D03 and D04) are restructured so that the concentration of hexachlorobenzene in fruit is calculated from the concentration of hexachlorobenzene in soil and an accumulation factor from soil to plants.

REVISION HISTORY

No revisions required in response to peer review in November/December, 2004. Note that the discussion in the body of the risk assessment (in which the chronic RfD was mistyped) did not impact these worksheets which correctly give the chronic RfD as 0.0008 mg/kg/day.

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Hexachlorobenzene in Clopyralid
WS Version 2.04**

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GENERAL ASSUMPTIONS, VALUES, and MODELS

Worksheet A01 [CONST]: Constants and conversion factors used in calculations

Conversion	ID	Value
mg/lb	mg_lb	453,600
mL/gallon	ml_gal	3,785
lb/gallon to mg/mL	lbg_mgml	119.8
lb/acre to $\mu\text{g}/\text{cm}^2$	lbac_ugcm	11.21
lb/acre to mg/cm^2	lbac_mgcm	0.01121
gallons to liters	gal_lit	3.785

Worksheet A02 [STD]: General Assumptions Used in Worker Exposure Assessments

Parameter	ID	Value	Units	Reference
Body Weight (General)	BW	70	kg	ICRP (1975), p. 13
Surface area of both hands	Hands	840	cm^2	U.S. EPA/ORD 1992, p. 8-11
Surface area of lower legs	LLegs	2070	cm^2	U.S. EPA/ORD 1992, p. 8-11
Weight of liquid adhering to surface of skin after a spill	Liq	0.008	mL/cm^2	Mason and Johnson 1987

Worksheet A03 [PUBL]: General Assumptions Used in Exposure Assessments for the General Public

Verbal Description: This table contains various values used in the exposure assessments for the general public. Three general groups of individuals are considered: adult male, adult female, and a 2 year old child. Values are specified for body weight, surface areas for various parts of the body, water intake, fish consumption, and the consumption of fruits or vegetables. Not all types of value are specified for each group. The only values specified are those used in the risk assessment.

Description	ID	Value	Units	Reference
Body Weights				
Male, Adult	BWM	70	kg	ICRP (1975), p. 13.
Female, Adult	BWF	64	kg	See Note 1 below.
Child, 2-3 years old	BWC	13.3	kg	U.S. EPA/ORD 1996, p. 7-1, Table 7-2
<p>¹This is the average value (63.79 kg), rounded to the nearest kg for 3 different groups of women between 15-49 years old: control (62.07 kg), pregnant (65.90 kg), and lactating (63.48 kg). See Burnmaster 1998, Table III, p.218. This is identical to the body weight for females, 45-55 years old, 50th percentile from U.S. EPA, 1985, page 5, Table 2-2, rounded to nearest kilogram.</p>				
Body Surface Areas				
Female, feet and lower legs	SAF1	2915	cm ²	U.S. EPA/ORD 1992, p. 8-11, Table 8-3, total for feet and lower legs
Female, exposed skin when wearing shorts and a T-shirt	SAF2	5300	cm ²	U.S. EPA/ORD 1992, p. 8-11, Table 8-3, total for arms, hands, lower legs, and feet.
Child, male, 2-3 years old, total body surface area	SAC	6030	cm ²	U.S. EPA/ORD 1996, p. 6-15, Table 6-6, 50 th percentile.
Water Intake				
Adult				
typical	WCAT	2	L/day	U.S. EPA/ORD 1996, p. 3-28, Table 3-30, midpoint of mean (1.4 L/day) and 90 th percentile (2.4 L/day) rounded to one significant place.
lower range for exposure assessment	WCAL	1.4	L/day	U.S. EPA/ORD 1996, p. 3-28, Table 3-30, mean
upper range	WCAH	2.4	L/day	U.S. EPA/ORD 1996, p. 3-28, Table 3-30, 90 th percentile
Child, < 3 years old				
typical	WCT	1	L/day	U.S. EPA/ORD 1996, p. 3-28, Table 3-30, midpoint of mean (0.61L/day) and 90 th percentile (1.5 L/day) rounded to one significant place.
lower range for exposure assessment	WCL	0.61	L/day	U.S. EPA/ORD 1996, p. 3-28, Table 3-30, mean
upper range	WCH	1.50	L/day	U.S. EPA/ORD 1996, p. 3-28, Table 3-30, 90 th percentile

Worksheet A03 [PUBL](continued): General Assumptions Used in Exposure Assessments for the General Public

Description	ID	Value	Units	Reference
Fish Consumption				
Freshwater anglers, typical intake per day over a prolonged period	FAT	0.010	kg/day	U.S. EPA/ORD 1996, p. 10-51, average of means from four studies rounded to one significant place.
Freshwater anglers, maximum consumption for a single day	FAU	0.158	kg/day	Ruffle et al. 1994
Native American subsistence populations, typical intake per day	FNT	0.081	kg/day	U.S. EPA/ORD 1996, p. 10-51, median value of 94 individuals
Native American subsistence populations, maximum for a single day	FNU	0.770	kg/day	U.S. EPA/ORD 1996, p. 10-51, highest value of 94 individuals
Consumption of Fruits and Vegetables				
Consumption of fruit, total				
Central	FrTC	0.00168	kg fruit/kg bw/day	U.S. EPA/ORD 1996, Table 9-3, p. 9-11, Central and upper estimates are mean and 95 th percentile, respectively. The 5 th percentile is given as zero. For these worksheets, the central estimate is used for the lower bound.
Lower	FrTL	0.00168		
Upper	FrTU	0.01244		
Consumption of vegetables, total				
Central	VgTC	0.0036	kg veg/kg bw/day	U.S. EPA/ORD 1996, Table 9-12, p. 9-12, mean, 5 th percentile and 95 th percentile.
Lower	VgTL	0.00075		
Upper	VgTU	0.01		
Consumption of vegetables, homegrown				
Central	VgHC	0.000761	kg veg/kg bw/day	U.S. EPA/ORD 1996, Table 12-15, p. 9-14, mean, 5 th percentile and 95 th percentile for individuals between 20 and 39 years old..
Lower	VgHL	0.0000777		
Upper	VgHU	0.00492		
Worst-case scenario for consumption in a single day, acute exposure scenario only.	VAcute	0.454	kg food	1 lb. The approximate mid range of the above typical and upper limits based on the 64 kg body weight.
Miscellaneous				
Estimate of dislodgeable residue as a proportion of application rate shortly after application.	DisL	0.1	none	Harris and Solomon 1992, data on 2,4-D

Worksheet A04 [HK]: Estimated pesticide residues on various types of vegetation shortly after an application of 1 lb/acre.

Type of Vegetation	Concentration (mg chemical/kg vegetation)			
	Typical		Upper Limit	
	ID	Value	ID	Value
The following values are from Hoerger and Kenaga (1972).				
Range grass	RGT	125	RGU	240
Grass	GST	92	GSU	110
Leaves and leafy crops	LVT	35	LVU	125
Forage crops	FCT	33	FCU	58
Pods containing seeds	PDT	3	PDU	12
Grain	GNT	3	GNU	10
Fruit	FRT	1.5	FRU	7

The following values are from Fletcher et al. (1994)

Short grass	SGT	85	SGU	240
Tall grass	TGT	36	TGU	110
Broadleaf/forage plants and small insects	BLT	45	BLU	135
Fruits, pods, seeds, and large insects	FRT2	7	FRU2	15

Worksheet A05 [FRUIT]: Concentration of a chemical on spheres of various sizes at an application rate of 1 lb/acre.

Diameter (cm)	Planar Surface Area (cm ²) ^a	Amount deposited (mg) ^b	Weight of sphere (kg) ^c	Concentration (mg/kg) ^d
1	0.78540	0.00880	0.00052	16.8
5	19.63495	0.21991	0.06545	3.36
10	78.53982	0.87965	0.52360	1.68
Application rate 1 lb/acre =			0.0112	mg/cm ²

a Planar surface area of a sphere = πr^2 where r is the radius in cm.

b Amount deposited is calculated as the application rate in mg/cm² multiplied by the planar surface area.

c Assumes a density of 1 g/cm³ for the fruit. The volume of a sphere is $(1 \div 6) \times \pi \times d^3$ where d is the diameter in cm. Assuming a density of 1 g/cm³, the weight of the sphere in kg is equal to:

$$\text{kg} = (1 \div 6) \times \pi \times d^3 \div 1000$$

d Amount of chemical in mg divided by the weight of the sphere in kg.

Worksheet A06 [OFFSITE]: Central estimates of off-site drift (expressed as fraction of application rate) associated with ground applications of pesticides ¹ (from AgDRIFT Version 1.16, Teske et al. 2001)

Distance Down Wind (feet)	Low Boom	High Boom	Orchard Airblast (Normal)
25	0.0187	0.1034	0.0057
50	0.0101	0.0515	0.0029
100	0.0058	0.0262	0.0007
300	0.0024	0.0078	0.0001
500	0.0015	0.0038	0.0000403
900	0.0008	0.0015	0.000013
990	0.0007	0.0013	< 0.0000108

¹ Estimates based on very fine to fine spray. This will over-estimate drift for applications involving larger droplets.

Worksheet A07a [KAMODEL]: Estimate of first-order absorption rate (k_a in hour⁻¹) and 95% confidence intervals (from SERA 1997).

Model parameters	ID	Value	
Coefficient for $k_{o/w}$	C_KOW	0.233255	
Coefficient for MW	C_MW	0.005657	
Model Constant	C	1.49615	
Number of data points	DP	29	
Degrees of Freedom (d.f.)	DF	26	
Critical value of $t_{0.025}$ with 26 d.f. ¹	CRIT	2.056	
Standard error of the estimate	SEE	16.1125	
Mean square error or model variance	MDLV	0.619712	
Standard deviation of model (s)	MSD	0.787218	MDLV ^{0.5}
X'X, cross products matrix	0.307537	-0.00103089	0.00822769
	-0.00103089	0.000004377	-0.0000944359
	0.0082	-0.0000944359	0.0085286

¹ Mendenhall and Scheaffer 1973, Appendix 3, 4, p. A31.

Central (maximum likelihood) estimate:

$$\log_{10} k_a = 0.233255 \log_{10}(k_{o/w}) - 0.005657 MW - 1.49615$$

95% Confidence intervals for $\log_{10} k_a$

$$\log_{10} k_a \pm t_{0.025} \times s \times (a'X'X a)^{0.5}$$

where a is a column vector of $\{1, MW, \log_{10}(k_{o/w})\}$.

NB: Although the equation for the central estimate is presented with $k_{o/w}$ appearing before MW to be consistent with the way a similar equation is presented by EPA, MW must appear first in column vector a because of the way the statistical analysis was conducted to derive X'X .

See following page for details of calculating $a'X'X a$ without using matrix arithmetic.

Worksheet Worksheet A07a (continued)

Details of calculating $a'X'Xa$

The term $a'(X'X)^{-1}a$ requires matrix multiplication. While this is most easily accomplished using a program that does matrix arithmetic, the calculation can be done with a standard calculator.

Letting

$$\mathbf{a} = \{a_1, a_2, a_3\}$$

and

$$(X'X)^{-1} = \begin{Bmatrix} \{b_1, b_2, b_3\}, \\ \{c_1, c_2, c_3\}, \\ \{d_1, d_2, d_3\} \\ \} \end{Bmatrix}$$

$a'(X'X)^{-1}a$ is equal to

$$\begin{aligned} \text{Term 1:} & \{a_1 \times ([a_1 \times b_1] + [a_2 \times c_1] + [a_3 \times d_1])\} + \\ \text{Term 2:} & \{a_2 \times ([a_1 \times b_2] + [a_2 \times c_2] + [a_3 \times d_2])\} + \\ \text{Term 3:} & \{a_3 \times ([a_1 \times b_3] + [a_2 \times c_3] + [a_3 \times d_3])\}. \end{aligned}$$

Worksheet A07b [KPMODEL]: Estimate of dermal permeability (K_p in cm/hr) and 95% confidence intervals (data from U.S. EPA/ORD 1992).

Model parameters	ID	Value	
Coefficient for $k_{o/w}$	C_KOW	0.706648	
Coefficient for MW	C_MW	0.006151	
Model Constant	C	2.72576	
Number of data points	DP	90	
Degrees of Freedom (d.f.)	DF	87	
Critical value of $t_{0.025}$ with 87 d.f. ¹	CRIT	1.96	
Standard error of the estimate	SEE	45.9983	
Mean square error or model variance	MDLV	0.528716	
Standard deviation of model (s)	MSD	0.727129	MDLV ^{0.5}
X'X, cross products matrix		0.0550931	-0.0000941546
		-0.0000941546	0.0000005978
		-0.0103443	-0.0000222508
		-0.0103443	0.00740677

¹ Mendenhall and Scheaffer, 1973, Appendix 3, Table 4, p. A31.

NOTE: The data for this analysis is taken from U.S. EPA/ORD (1992), Dermal Exposure Assessment: Principles and Applications, EPA/600/8-91/011B, Table 5-4, pp. 5-15 through 5-19. The EPA report, however, does not provide sufficient information for the calculation of confidence intervals. The synopsis of the above analysis was conducted in STATGRAPHICS Plus for Windows, Version 3.1 (Manugistics, 1995) as well as Mathematica, Version 3.0.1.1 (Wolfram Research, 1997). Although not explicitly stated in the EPA report, 3 of the 93 data points are censored from the analysis because they are statistical outliers: [Hydrocortisone-21-yl]-hemipimelate, n-nonanol, and n-propanol. The model parameters reported above are consistent with those reported by U.S. EPA but are carried out to greater number of decimal places to reduce rounding errors when calculating the confidence intervals. See notes to Worksheet A07a for details of calculating maximum likelihood estimates and confidence intervals.

CHEMICAL SPECIFIC VALUES

Worksheet B01 [APPL]: Anticipated Application and Dilution Rates

Item	Code	Value	Units	Source
Application rate for clopyralid				
	Central Typ	0.35	lbs/acre	Section 2.4
	Lower Low	0.35		Section 2.4
	Upper Hi	0.35		Section 2.4
Proportion of hexachlorobenzene in clopyralid		0.0000025	equivalent to 2.5 ppm	Section 2.2
Function Application rate of hexachlorobenzene (<i>R</i>)	Calculated as the application rate for clopyralid multiplied by the proportion of hexachlorobenzene in clopyralid.			
	Central Typ	8.75e-07	lbs/acre	
	Lower Low	8.75e-07		
	Upper Hi	8.75e-07		
Dilution (<i>Dil</i>)				
	Central CDil	30	gal./acre	Section 2.4
	Lower LDil	5		
	Upper HDil	100		
Concentration in field solutions ¹ : $R_{(lb/acre)} \div Dil_{(gal/acre)} \times 119.8 \text{ mg/mL} \div lb/gal$				
	Central TypDr	3.0e-06	mg/mL	
	Lower LowDr	1.0e-06		
	Upper HI_Dr	2.1e-05		

The typical concentration in applied solution is calculated as the typical application rate (lbs/acre) divided by the typical dilution (gal/acre), yielding units of lbs/gallon. This is converted to mg/mL using the relationship of lb/gal = 119.8 mg/mL from Worksheet A01. The lowest estimated concentration is calculated as the lowest application rate divided by the highest dilution. The highest estimated concentration is calculated as highest application rate divided by the lowest dilution.

Worksheet B02 [CHEM]: Summary of chemical specific values used in exposure assessment worksheets.

Parameter	ID	Value	Units	Source/Reference
Molecular weight, acid	MW	284	grams/mole	Budavari 1989
Water Solubility, salt	WS	0.006	mg/L	ATSDR 2002
$K_{o/w}$	Kow	1,510,000	unitless	ATSDR 2002 (given as log $K_{o/w}$ of 6.18)
Bioconcentration factor, edible portion, acute exposure	BCFT	2000	L/kg fish	Section 3.2.4.3
Bioconcentration factor, edible portion, chronic exposure	BCFCh	20000	L/kg fish	
Bioconcentration factor, whole fish, acute	BCFWA	2000	L/kg fish	
Bioconcentration factor, whole fish, chronic	BCFWC	20000	L/kg fish	
Bioconcentration factor from soil for plants	BCF_P	19	kg/kg plant	Section 3.2.4.4
Chronic RfD ^a	RfD_USED	0.0008	mg/kg bw/day	Section 3.3.3
Acute RfD	RfDA	0.008	mg/kg bw/day	
Cancer Potency Factor	Q1	1.6	(mg/kg bw/day) ⁻¹	

Worksheet B03 [KA_CHEM]: Calculation of first-order dermal absorption rate (k_a)¹.

Parameters	Value	Units	Reference
Molecular weight	284	g/mole	
$K_{o/w}$ at pH 7	1510000	unitless	
$\log_{10} K_{o/w}$	6.18		
Column vector \mathbf{a} for calculating confidence intervals			
a_1	1		
a_2	284		
a_3	6.18		
Calculation of $\mathbf{a}' \cdot (\mathbf{X}'\mathbf{X})^{-1} \cdot \mathbf{a}$			
Term 1	0.06544024		
Term 2	-0.10548778481		
Term 3	0.21082849003		
$\mathbf{a}' \cdot (\mathbf{X}'\mathbf{X})^{-1} \cdot \mathbf{a}$	0.1708		
$\log_{10} k_a = 0.233255 \log_{10}(k_{o/w}) - 0.005657 MW - 1.49615$			
\log_{10} of first order absorption rate (k_a)			
Central estimate	-1.66146073216	$\pm t_{0.025}$	$\times s \times (\mathbf{a}' \cdot (\mathbf{X}'\mathbf{X})^{-1} \cdot \mathbf{a})^{0.5}$
Lower limit	-2.33036206192	- 2.0560	$\times 0.787218 \times 0.4132795664$
Upper limit	-0.99255940239	+ 2.0560	$\times 0.787218 \times 0.4132795664$
First order absorption rates (i.e., antilog or 10^x of above values).			
Central estimate	0.0218041554	hour ⁻¹	
Lower limit	0.004673454	hour ⁻¹	
Upper limit	0.1017280214	hour ⁻¹	

¹ See Worksheet A07a for details of method.

Worksheet B04 [KP_CHEM]: Calculation of dermal permeability rate (K_p) in cm/hour¹.

Parameters	Value	Units	Reference
Molecular weight	284	g/mole	
$K_{o/w}$	1510000	unitless	
$\log_{10} K_{o/w}$	6.17897694729		

Column vector \mathbf{a} for calculating confidence intervals

a_1	1
a_2	284
a_3	6.17897694729

Calculation of $\mathbf{a}' \cdot (\mathbf{X}'\mathbf{X})^{-1} \cdot \mathbf{a}$

Term 1	-0.0355639976
Term 2	-0.0175701088
Term 3	0.17982512177

$$\mathbf{a}' \cdot (\mathbf{X}'\mathbf{X})^{-1} \cdot \mathbf{a} = 0.1267$$

$$\log_{10} K_p = 0.706648 \log_{10}(k_{o/w}) - 0.006151 MW - 2.72576$$

\log_{10} of dermal permeability

Central estimate	-0.10628229815	$\pm t_{0.025}$	$\times s$	$\times \mathbf{a}' \cdot (\mathbf{X}'\mathbf{X})^{-1} \cdot \mathbf{a}^{0.5}$
Lower limit	-0.61357176477	- 1.9600	$\times 0.727129$	$\times 0.35594943461$
Upper limit	0.40100716847	+ 1.9600	$\times 0.727129$	$\times 0.35594943461$

Dermal permeability

Central estimate	7.83e-01	cm/hour
Lower limit	2.43e-01	cm/hour
Upper limit	2.52e+00	cm/hour

¹ See Worksheet A07a for details of method.

Worksheet B05 [DERM]: Summary of chemical specific dermal absorption values.

Description	Code	Value	Units	Reference/Source
Zero-order absorption (K_p)				
Central estimate	KpC	0.78	cm/hour	Worksheet KPMODEL, values rounded to two significant figures
Lower limit	KpL	0.24	cm/hour	
Upper limit	KpU	2.5	cm/hour	
First-order absorption rates (k_a)				
Central estimate	AbsC	0.022	hour ⁻¹	Worksheet KAMODEL, values rounded to two significant figures
Lower limit	AbsL	0.0047	hour ⁻¹	
Upper limit	AbsU	0.1	hour ⁻¹	

Worksheet B06 [AMBWAT]: Estimates of the concentrations in ambient water per pound applied per acre are used in the chronic contaminated water exposure assessments.

Scenario	ID	WCR (mg/L) ÷ (lb/acre)
Short-term Peak Concentrations in Streams (See 3.2.3.4.1)		
Central Based on GLEAMS modeling.	AWPT	0.09
Lower	AWPL	0.001
Upper	AWPU	0.3
Longer-term Concentrations in Streams (See Section 3.2.3.4.2 for details)		
Central Based on GLEAMS modeling.	AWT	0.0005
Lower	AWL	0.00003
Upper	AWU	0.001

WORKER EXPOSURE ASSESSMENTS

Worksheet C01a: Worker exposure estimates for directed foliar (backpack) applications [WkBkExp01]

Verbal Description: The absorbed dose for the worker is calculated from the amount handled per day and the generic absorbed dose rate from several field studies on worker applications of a number of herbicides. The amount handled per day is calculated from the application rates as well as estimates of the hours worked per day and acres treated per hour.

Parameter/Assumption		Value	Units	Source/Designation
Application rates (R)				
	Central	8.75e-07	lb/acre	APPL.TYP
	Lower	8.75e-07		APPL.LOW
	Upper	8.75e-07		APPL.HI
Hours of application per day (Hrs)				
	Central	7	hours	USDA 1989a,b,c
	Lower	6		USDA 1989a,b,c
	Upper	8		USDA 1989a,b,c
Acres treated per hour (Acres)				
	Central	0.625	acres/hour	USDA 1989a,b,c
	Lower	0.25		USDA 1989a,b,c
	Upper	1		USDA 1989a,b,c
Acres treated per day (ATD): Hrs × Acres				
	Central	4.375	acres/day	
	Lower	1.5		
	Upper	8		
Amount handled per day (AHD): R × ATD				
	Central	3.83e-06	lb/day	
	Lower	1.31e-06		
	Upper	7.00e-06		
Absorbed dose rate (ADR):				
	Central	0.003	(mg agent/kg bw)	SERA 2001
	Lower	0.0003	÷ (lbs agent	
	Upper	0.01	handled per day)	
Absorbed dose [D_{Abs}]: AHD × ADR				
	Central	1.15e-08	mg/kg bw/day	
	Lower	3.94e-10		
	Upper	7.00e-08		

Worksheet C01b: Worker exposure estimates for boom spray (hydraulic ground spray) applications
 [WkHyExp01]

Verbal Description: The absorbed dose for the worker is calculated from the amount handled per day and the generic absorbed dose rate from several field studies on worker applications of a number of herbicides. The amount handled per day is calculated from the application rates as well as estimates of the hours worked per day and acres treated per hour.

Parameter/Assumption	Value	Units	Source/Designation
Application rates (<i>R</i>)			
Central	8.75e-07	lb/acre	APPL.TYP
Lower	8.75e-07		APPL.LOW
Upper	8.75e-07		APPL.HI
Hours of application per day (<i>Hrs</i>)			
Central	7	hours	USDA 1989a,b,c
Lower	6		
Upper	8		
Acres treated per hour (<i>Acres</i>)			
Central	16	acres/hour	USDA 1989a,b,c.
Lower	11		
Upper	21		
Acres treated per day (<i>ATD</i>): $Hrs \times Acres$			
Central	112	acres/day	
Lower	66		
Upper	168		
Amount handled per day (<i>AHD</i>): $R \times ATD$			
Central	9.80e-05	lb/day	
Lower	5.78e-05		
Upper	1.47e-04		
Absorbed dose rate (<i>ADR</i>)			
Central	2.00e-04	(mg agent/kg bw)	SERA 2001
Lower	1.00e-05	÷ (lbs agent	
Upper	9.00e-04	handled per day)	
Absorbed dose [D_{Abs}]: $AHD \times ADR$			
Central	1.96e-08	mg/kg bw/day	
Lower	5.78e-10		
Upper	1.32e-07		

Worksheet C01c: Worker exposure estimates for aerial applications [WKAREXP01]

Verbal Description: The absorbed dose for the worker is calculated from the amount handled per day and the generic absorbed dose rate from several field studies on worker applications of a number of herbicides (SERA 2001). The amount handled per day is calculated from the application rates as well as estimates of the hours worked per day and acres treated per hour.

Parameter/Assumption	Value	Units	Source/Designation
Application rates (<i>R</i>)			
Central	8.75e-07	lb/acre	Appl.Typ
Lower	8.75e-07		Appl.Low
Upper	8.75e-07		Appl.Hi
Hours of application per day (<i>Hrs</i>)			
Central	7	hours	USDA 1989a,b,c
Lower	6		
Upper	8		
Acres treated per hour (<i>Acres</i>)			
Central	70	acres/hour	USDA 1989a,b,c
Lower	40		
Upper	100		
Acres treated per day (<i>ATD</i>): $Hrs \times Acres$			
Central	490	acres/day	
Lower	240		
Upper	800		
Amount handled per day (<i>AHD</i>): $R \times ATD$			
Central	4.29e-04	lb/day	
Lower	2.10e-04		
Upper	7.00e-04		
Absorbed dose rate (<i>ADR</i>)			
Central	3.00e-05	(mg agent/kg bw)	SERA 2001
Lower	1.00e-06	÷ (lbs agent handled per day)	
Upper	1.00e-04		
Absorbed dose [D_{Abs}]: $AHD \times ADR$			
Central	1.29e-08	mg/kg bw	
Lower	2.10e-10		
Upper	7.00e-08		

Worksheet C02a: Workers: Accidental Dermal Exposure Assessments Using Zero-Order Absorption Wearing Contaminated Gloves for One Minute [WrkDrmZr01]

Verbal Description: Dermal absorption is calculated using the zero-order model from U.S. EPA/ORD (1992):

$$\text{Dose (mg/kg)} = K_p \times C \times \text{Time} \times S \div W$$

Each of the above terms are described below.

Parameter		Value	Units	Source
Body weight (<i>W</i>)		70	kg	STD.BW
Surface Area of hands (<i>S</i>)		840	cm ²	STD.Hands
Dermal permeability (<i>K_p</i>)	Central	7.80e-01	cm/hour	DERM.KpC
	Lower	2.40e-01	cm/hour	DERM.KpL
	Upper	2.50e+00	cm/hour	DERM.KpU
Concentration in solution (<i>C</i>) ¹	Central	0.000003	mg/mL	APPL.TypDr
	Lower	0.000001	mg/mL	APPL.LowDr
	Upper	0.000021	mg/mL	APPL.HI_Dr
Duration of Exposure (<i>T</i>)		0.0167	hours	1÷60
Absorbed Dose (<i>D_{Abs}</i>): $K_p \times C \times T \times S \div W$	Central	4.68e-07	mg/kg	
	Lower	4.80e-08	mg/kg	
	Upper	1.05e-05	mg/kg	

¹ Note that 1 mL is equal to 1 cm³ and thus mg/mL = mg/cm³.

Worksheet C02b: Workers: Accidental Dermal Exposure Assessments Using Zero-Order Absorption Wearing Contaminated Gloves for One Hour [WrkDrmZr60]

Verbal Description: Dermal absorption is calculated using the zero-order model from U.S. EPA/ORD (1992):

$$\text{Dose (mg/kg)} = K_p \times C \times \text{Time} \times S \div W$$

Each of the above terms are described below.

Parameter	Value	Units	Source
Body weight (<i>W</i>)	70	kg	STD.BW
Surface Area of hands (<i>S</i>)	840	cm ²	STD.Hands
Dermal permeability (<i>K_p</i>)			
Central	7.80e-01	cm/hour	DERM.KpC
Lower	2.40e-01		DERM.KpL
Upper	2.50e+00		DERM.KpU
Concentration in solution (<i>C</i>) ¹			
Central	0.000003	mg/mL	APPL.TypDr
Lower	0.000001		APPL.LowDr
Upper	0.000021		APPL.HI_Dr
Duration of Exposure (<i>T</i>)	1	hours	
Absorbed Dose (<i>D_{Abs}</i>): $K_p \times C \times T \times S \div W$			
Central	2.81e-05	mg/kg bw	
Lower	2.88e-06		
Upper	6.30e-04		

¹ Note that 1 mL is equal to 1 cm³ and thus mg/mL = mg/cm³.

Worksheet C03a: Accidental Spill onto the Hands for 1 Hour Based on the Assumption of First-Order Absorption [WrkDrmFrHnd]

Verbal Description: A worker spills a solution of the compound at a specified concentration (C) on a defined area of the skin (A). Based on the amount of liquid adhering to the skin (L), the amount of chemical absorbed ($Dose$) over a given period is calculated from the first order dermal absorption coefficient (k_a), the amount of time that the chemical remains on the surface of the skin before it is effectively removed by washing (T) and the body weight (W) (Durkin et al. 1995).

Parameter	Value	Units	Source
Liquid adhering to skin after a spill (L)	0.008	mL/cm ²	STD.Liq
Body weight (W)	70	kg	STD.BW
Surface Areas (A)			
Hands	840	cm ²	STD.Hands
Duration of Exposure (T)	1	hours	
First-order dermal absorption rates (k_a)			
Central	0.02200	hour ⁻¹	DERM.ABSC
Lower	0.004700		DERM.ABSL
Upper	0.10000		DERM.ABSU
Concentration in solution (C)			
Central	0.000003	mg/mL	APPL.TypDr
Lower	0.000001		APPL.LowDr
Upper	0.000021		APPL.HI_Dr
Amount Deposited on Skin ($Amnt$): $L \times A \times C$			
Central	0.0000202	mg	
Lower	0.000007		
Upper	0.00014112		
Proportion absorbed over period T ($Prop$): $1 - e^{-k_a T}$			
Central	0.0217598	unitless	
Lower	0.0046890		
Upper	0.0951626		
Absorbed Dose (D_{Abs}): $Amnt \times Prop \div W$			
Central	6.27e-09	mg/kg bw	
Lower	4.50e-10		
Upper	1.92e-07		

Worksheet C03b: Accidental Spill onto the Lower Legs for 1 Hour Based on the Assumption of First-Order Absorption [WrkDrmFrLeg]

Verbal Description: A worker spills a solution of the compound at a specified concentration (C) on a defined area of the skin (A). Based on the amount of liquid adhering to the skin (L), the amount of chemical absorbed ($Dose$) over a given period is calculated from the first order dermal absorption coefficient (k_a), the amount of time that the chemical remains on the surface of the skin before it is effectively removed by washing (T) and the body weight (W) (Durkin et al. 1995).

Parameter	Value	Units	Source
Liquid adhering to skin after a spill (L)	0.008	mL/cm ²	STD.Liq
Body weight (W)	70	kg	STD.BW
Surface Areas (A)			
Legs	2070	cm ²	STD.LLegs
Duration of Exposure (T)	1	hours	
First-order dermal absorption rates (k_a)			
Central	0.02200	hour ⁻¹	DERM.ABSC
Lower	0.004700		DERM.ABSL
Upper	0.10000		DERM.ABSU
Concentration in solution (C)			
Central	0.000003	mg/mL	APPL.TypDr
Lower	0.000001		APPL.LowDr
Upper	0.000021		APPL.HI_Dr
Amount Deposited on Skin ($Amnt$): $L \times A \times C$			
Central	0.0000497	mg	
Lower	0.0000166		
Upper	0.00034776		
Proportion absorbed over period T ($Prop$): $1 - e^{-k_a T}$			
Central	0.0217598	unitless	
Lower	0.0046890		
Upper	0.0951626		
Absorbed Dose (D_{Abs}): $Amnt \times Prop \div W$			
Central	1.54e-08	mg/kg bw	
Lower	1.11e-09		
Upper	4.73e-07		

EXPOSURE ASSESSMENTS FOR THE GENERAL PUBLIC

Worksheet D01a: Direct Spray of a Child, Assumption of First-Order Absorption [SpillFOACh01]

Verbal Description: A naked child is accidentally sprayed over the entire body surface (*A*) with a field dilution of a specified concentration (*C*). The child is effectively washed - i.e., all of the compound is removed - after a specified period of time (*T*). The absorbed dose (*D*) is calculated from the amount of liquid adhering to the skin (*L*), the first-order dermal absorption rate (*k_a*) and the body weight (*W*).

Parameter	Value	Units	Source
Liquid adhering to skin after a spill (<i>L</i>)	0.008	mL/cm ²	STD.Liq
Body weight (<i>W</i>)	13.3	kg	PUBL.BWC
Exposed surface area (<i>A</i>)			
Whole Body	6030	cm ²	PUBL.SAC
Duration of Exposure (<i>T</i>)	1	hours	
First-order dermal absorption rates (<i>k_a</i>)			
Central	0.022	hour ⁻¹	DERM.ABSC
Lower	0.0047		DERM.ABSL
Upper	0.1		DERM.ABSU
Concentration in solution (<i>C</i>)			
Central	0.000003	mg/mL	APPL.TypDr
Lower	0.000001		APPL.LowDr
Upper	0.000021		APPL.HI_Dr
Amount Deposited on Skin (<i>Amnt</i>): $L \times A \times C$			
Central	0.00014472	mg	
Lower	0.0000482		
Upper	0.00101304		
Proportion absorbed over period <i>T</i> (<i>Prop</i>): $1 - e^{-kT}$			
Central	0.0217598	unitless	
Lower	0.0046890		
Upper	0.0951626		
Absorbed Dose (<i>D_{Abs}</i>): $Amnt \times Prop \div W$			
Central	2.37e-07	mg/kg bw	
Lower	1.70e-08		
Upper	7.25e-06		

Worksheet D01b: Direct Spray of a Woman, Assumption of First-Order Absorption [SpillFOAWm01]

Verbal Description: A woman is sprayed over the feet and lower legs (*A*) with a field dilution of a specified concentration (*C*). The woman effectively washes - i.e., all of the compound is removed - after a specified period of time (*T*). The absorbed dose (*D*) is calculated from the amount of liquid adhering to the skin (*L*), the first-order dermal absorption rate (*k_a*) and the body weight (*W*).

Parameter	Value	Units	Source
Liquid adhering to skin after a spill (<i>L</i>)	0.008	mL/cm ²	STD.Liq
Body weight (<i>W</i>)	64	kg	PUBL.BWF
Exposed surface area (<i>A</i>)			
Feet and lower legs	2915	cm ²	PUBL.SAF1
Duration of Exposure (<i>T</i>)	1	hours	
First-order dermal absorption rates (<i>k_a</i>)			
Central	0.02200	hour ⁻¹	DERM.ABSC
Lower	0.004700		DERM.ABSL
Upper	0.10000		DERM.ABSU
Concentration in solution (<i>C</i>)			
Central	0.000003	mg/mL	APPL.TypDr
Lower	0.000001		APPL.LowDr
Upper	0.000021		APPL.HI_Dr
Amount Deposited on Skin (<i>Amnt</i>): $L \times A \times C$			
Central	0.00007	mg	
Lower	0.0000233		
Upper	0.00048972		
Proportion absorbed over period <i>T</i> (<i>Prop</i>): $1 - e^{-k_a T}$			
Central	0.0217598	unitless	
Lower	0.0046890		
Upper	0.0951626		
Absorbed Dose (<i>D_{Abs}</i>): $Amnt \times Prop \div W$			
Central	2.38e-08	mg/kg	
Lower	1.71e-09		
Upper	7.28e-07		

Worksheet D02: Dermal contact with contaminated vegetation by a young woman [VegC_FOA01].

Verbal Description: A woman wearing shorts and a short sleeved shirt is in contact with contaminated vegetation for 1 hour shortly after application of the compound - i.e. no dissipation or degradation is considered. The chemical is effectively removed from the surface of the skin - i.e., washing - after 24 hours.

Parameter/Assumption	Value	Units	Source/Reference
Contact time (T_c)	1	hour	N/A
Exposure time (T_e)	24	hours	N/A
Body weight (W)	64	kg	PUBL.BWF
Exposed surface area (A)	5300	cm ²	PUBL.SAF2
Application Rates in lb/acre (R_{lb})			
Central	8.75e-07	lb/acre	APPL.TYP
Lower	8.75e-07		APPL.LOW
Upper	8.75e-07		APPL.HI
First-order dermal absorption rate (k)			
Central	0.02200	hour ⁻¹	DERM.AbsC
Lower	0.004700		DERM.AbsL
Upper	0.10000		DERM.AbsU
Application Rates in $\mu\text{g}/\text{cm}^2$ ($R_{\mu\text{g}}$): $R_{lb} \times \text{Const.lbac}_{\mu\text{gcm}}$			
Central	9.81e-06	$\mu\text{g}/\text{cm}^2$	
Lower	9.81e-06		
Upper	9.81e-06		
Proportion dislodgeable ($PropDr$)	0.1	none	PUBL.DisL
Dislodgeable residue (Dr): $R_{\mu\text{g}} \times PropDr$			
Central	9.81e-07	$\mu\text{g}/\text{cm}^2$	
Lower	9.81e-07		
Upper	9.81e-07		
Transfer Rate (Tr): $Tr = 10^{(1.09 \times \log_{10}(Dr) + 0.05)} \div 1000$ $\mu\text{g}/\text{mg}$			
Central	3.17e-10	mg/(cm ² hr)	The method of Durkin et al. (1995, p. 68, equation 4) is used to calculate the transfer rate (Tr) in units of $\mu\text{g}/(\text{cm}^2 \cdot \text{hr})$ based on the dislodgeable residue (Dr) in units of $\mu\text{g}/\text{cm}^2$. This is converted to units of mg/(cm ² ·hr) by dividing by 1000 $\mu\text{g}/\text{mg}$.
Lower	3.17e-10		
Upper	3.17e-10		
Amount Transferred to Skin Surface ($Amnt$): $Tr \times T_c \times A$			
Central	1.68e-06	mg	
Lower	1.68e-06		
Upper	1.68e-06		
Proportion Absorbed ($PropAbs$): $1 - e^{-k_a \times T_e}$			
Central	4.10e-01	unitless	
Lower	1.07e-01		
Upper	9.09e-01		
Absorbed dose (D_{Abs}): $Amnt \times PropAbs \div W$			
Central	1.08e-08	mg/kg bw	
Lower	2.80e-09		
Upper	2.39e-08		

Worksheet D03: Consumption of contaminated fruit, acute exposure scenario [VegAcHHRA01].

Verbal Description: Edible fruit is contaminated by uptake from soil. The concentration of the chemical in fruit (*C*) is estimated from the bioconcentration factor from plants to soil..

Parameters/Assumptions	Value	Units	Source/Reference
Amount of fruit consumed per Unit Body Weight (<i>A</i>):			
Central	0.00168	kg fruit/kg bw/day	PUBL.FrTC
Lower	0.00168		PUBL.FrTL
Upper	0.01244		PUBL.FrTU
Concentration in soil at 1 lb/acre (<i>SCR</i>)			
Central	0.67	mg/kg soil per lb/acre	Section 3.2.4.2.
Lower	0.67		
Upper	0.67		
Functional Application Rate (<i>R</i>)			
Central	8.75e-07		Worksheet B01
Lower	8.75e-07		
Upper	8.75e-07		
Concentration in soil (<i>SCR</i> × <i>R</i>)			
Central	5.86e-07		
Lower	5.86e-07		
Upper	5.86e-07		
Bioconcentration factor from Soil to Plants			
Central	19	unitless	Worksheet B02
Lower	19		
Upper	19		
Concentration on fruit (<i>C</i>)			
Central	1.11e-05	mg/kg fruit	
Lower	1.11e-05		
Upper	1.11e-05		
Dose estimates (<i>D</i>): <i>C</i> × <i>A</i>			
Central	1.87e-08	mg/kg bw	
Lower	1.87e-08		
Upper	1.39e-07		

Worksheet D04: Consumption of contaminated fruit, chronic exposure scenario [VegCHHRA01].

Verbal Description: Edible fruit is contaminated by uptake from soil. The concentration of the chemical in fruit (*C*) is estimated from the bioconcentration factor from plants to soil..

Parameters/Assumptions	Value	Units	Source/Reference
Amount of fruit consumed per Unit Body Weight (<i>A</i>):			
Central	0.0017	kg fruit/kg bw/day	PUBL.FrTC
Lower	0.0017		PUBL.FrTL
Upper	0.01244		PUBL.FrTU
Concentration in soil at 1 lb/acre (<i>SCR</i>)			
Central	0.026	mg/kg soil per lb/acre	Section 3.2.4.2.
Lower	0.006		
Upper	0.031		
Functional Application Rate (<i>R</i>)			
Central	8.75e-07		Worksheet B01
Lower	8.75e-07		
Upper	8.75e-07		
Concentration in soil (<i>SCR</i> × <i>R</i>)			
Central	2.28e-08		
Lower	5.25e-09		
Upper	2.71e-08		
Bioconcentration factor from Soil to Plants			
Central	19	unitless	Worksheet B02
Lower	19		
Upper	19		
Concentration on fruit (<i>C</i>)			
Central	4.32e-07	mg/kg fruit	
Lower	9.98e-08		
Upper	5.15e-07		
Dose estimates (<i>D</i>): <i>C</i> × <i>A</i>			
Central	7.26e-10	mg/kg bw	
Lower	1.68e-10		
Upper	6.41e-09		

Worksheet D05: Consumption of contaminated water following an accidental spill, acute exposure scenario [DWAcHHRA01].

Verbal Description: A young child (2-3 years old) consumes contaminated water shortly after an accidental spill of 200 gallons of a field solution into a pond that has an average depth of 1 m and a surface area of 1000 m² or about one-quarter acre . No dissipation or degradation is considered.

Parameters/Assumptions	Value	Units	Source/Reference
Surface area of pond (SA)	1000	m ²	N/A
Average depth (DPTH)	1	m	N/A
Volume of pond in cubic meters (VM)	1000	m ³	N/A
Volume of pond in Liters (VL)	1000000	L	1 m ³ = 1,000 L
Volume of spill (VS)	200	gallons	N/A
	757	liters	1 gallon = 3.785 Liters
Concentrations in field solution (C_{Fld} (mg/L))			
Central	0.003	mg/L	APPL.TypDR × 1000
Lower	0.001		APPL.LowDR × 1000
Upper	0.021		APPL.Hi_DR × 1000
Concentrations in ambient water (C_{Wrt}): $C_{Fld} \times VS_{(Liters)} \div VL$			
Central	2.27e-06	mg/L	
Lower	7.57e-07		
Upper	1.59e-05		
Body weight (W)	13.3	kg	PUBL.BWC
Amount of water consumed (A)			
Central	1	L/day	PUBL.WCT
Lower	0.61		PUBL.WCL
Upper	1.5		PUBL.WCH
Dose estimates (D): $C_{wrt} \times A \div W$			
Central	1.71e-07	mg/kg bw	
Lower	3.47e-08		
Upper	1.79e-06		

Worksheet D06: Consumption of from a stream contaminated by runoff and/or percolation, acute exposure scenario [DWAcStrmHHRA01].

Verbal Description: A young child (2-3 years old) consumes contaminated ambient water from a stream that has been contaminated from run-off and/or percolation. The levels in water are estimated from modeling or monitoring data and thus dissipation, degradation and other environmental processes are implicitly considered. The calculations involve multiplying the application rate (**R**) by the water contamination rate to get the concentration in ambient water. This product is in turn multiplied by the amount of water consumed per day and then divided by the body weight to get the estimate of the absorbed dose.

Parameters/Assumptions	Value	Units	Source/Reference
Application Rates (R)			
Central	8.75e-07	lb/acre	APPL.Typ
Lower	8.75e-07		APPL.Low
Upper	8.75e-07		APPL.Hi
Water Contamination Rate (WCR):			
Central	0.09	mg/L per lb/acre applied	AMBWAT.AWPT
Lower	0.001		AMBWAT.AWPL
Upper	0.3		AMBWAT.AWPU
Body weight (W)	13.3	kg	PUBL.BWC
Amount of water consumed (A)			
Central	1	L/day	PUBL.WCT
Lower	0.61		PUBL.WCL
Upper	1.5		PUBL.WCH
Concentration in Water (C): $R \times WCR$			
Central	7.88e-08	mg/L	
Lower	8.75e-10		
Upper	2.63e-07		
Dose estimates (D): $C \times A \div W$			
Central	5.92e-09	mg/kg bw/day	
Lower	4.01e-11		
Upper	2.96e-08		

Worksheet D07: Consumption of contaminated water, chronic exposure scenario [DWChHHRA01].

Verbal Description: An adult (70 kg male) consumes contaminated ambient water for a lifetime. The levels in water are estimated from modeling or monitoring data and thus dissipation, degradation and other environmental processes are implicitly considered. The calculations involve multiplying the application rate by the water contamination rate to get the concentration in ambient water. This product is in turn multiplied by the amount of water consumed per day and then divided by the body weight to get the estimate of the absorbed dose.

Parameters/Assumptions		Value	Units	Source/Reference
Application Rates (<i>R</i>)				
	Central	8.75e-07	lb/acre	APPL.Typ
	Lower	8.75e-07		APPL.Low
	Upper	8.75e-07		APPL.Hi
Water Contamination Rate (<i>WCR</i>):				
	Central	5.00e-04	mg/L per lb/acre	AMBWAT.AWT
	Lower	3.00e-05	applied	AMBWAT.AWL
	Upper	1.00e-03		AMBWAT.AWU
Body weight (<i>W</i>)				
		70	kg	PUBL.BWM
Amount of water consumed (<i>A</i>)				
	Central	2	L/day	PUBL.WCAT
	Lower	1.4		PUBL.WCAL
	Upper	2.4		PUBL.WCAH
Concentration in Water (<i>C</i>): $R \times WCR$				
	Central	4.38e-10	mg/L	
	Lower	2.63e-11		
	Upper	8.75e-10		
Dose estimates (<i>D</i>): $C \times A \div W$				
	Central	1.25e-11	mg/kg bw/day	
	Lower	5.25e-13		
	Upper	3.00e-11		

Worksheet D08a: Consumption of contaminated fish, acute exposure scenarios for recreational fisherman following an accidental spill [FishAcHHRA01].

Verbal Description: An adult angler consumes fish taken from contaminated water shortly after an accidental spill of a fixed amount of a field solution into a pond of a specified depth and surface area. No dissipation or degradation is considered. As in the acute drinking water scenario, the concentration in the pond estimated from the concentration in the spilled solution, the volume spilled and the volume of the pond, assuming instantaneous mixing. The concentration in fish is estimated as the product of the concentration in water and the chronic BCF. The dose is calculated as the product of the concentration in the fish and the amount of fish consumed divided by the body weight.

Parameters/Assumptions	Value	Units	Source/Reference
Surface area of pond [SA]	1000	m ²	N/A
Average depth [DPTH]	1	m	N/A
Volume of pond in cubic meters [VM]	1000	m ³	N/A
Volume of pond in Liters [VL]	1000000	L	1 m ³ = 1,000 L
Volume of spill [VS]	200	gallons	N/A
	757	liters	1 gallon = 3.785 Liters
Concentrations in spilled solution (C_{Fld} (mg/L))			
Central	0.003	mg/L	APPL.TYPDR×1000
Lower	0.001		APPL.LOWDR×1000
Upper	0.021		APPL.HI_DR×1000
Concentrations in ambient water (C_{Wat}): $C_{Fld} \times VS_{(Liters)} \div VL$			
Central	2.27e-06	mg/L	
Lower	7.57e-07		
Upper	1.59e-05		
Bioconcentration factor ($BCF_{(L/kg\ fish)}$)	2000	L/kg fish	CHEM.BCFT
Concentration in fish (C_{Fish}): $C_{Wat} \times BCF$			
Central	0.004542	mg/kg fish	
Lower	0.001514		
Upper	0.031794		
Body weight (W)	70	kg	PUBL.BWM
Amount of fish consumed (A)			
Central	0.158	kg/day	PUBL.FAU
Lower	0.158		PUBL.FAU
Upper	0.158		PUBL.FAU
Dose estimates (D): $C_{Fish} \times A \div W$			
Central	1.03e-05	mg/kg bw	
Lower	3.42e-06		
Upper	7.18e-05		

Worksheet D08b: Consumption of contaminated fish, acute exposure scenarios for subsistence populations following an accidental spill [FishAcHHRA02].

Verbal Description: An individual who relies on caught fish as a major source of protein consumes fish taken from contaminated water shortly after an accidental spill of a fixed amount of a field solution into a pond of a specified depth and surface area. As in the acute drinking water scenario, the concentration in the pond estimated from the concentration in the spilled solution, the volume spilled and the volume of the pond, assuming instantaneous mixing. The concentration in fish is estimated as the product of the concentration in water and the chronic BCF. The dose is calculated as the product of the concentration in the fish and the amount of fish consumed divided by the body weight.

Parameters/Assumptions	Value	Units	Source/Reference
Surface area of pond [SA]	1000	m ²	N/A
Average depth [DPTH]	1	m	N/A
Volume of pond in cubic meters [VM]	1000	m ³	N/A
Volume of pond in Liters [VL]	1000000	L	1 m ³ = 1,000 L
Volume of spill [VS]	200	gallons	N/A
	757	liters	1 gallon = 3.785 Liters
Concentrations in spilled solution (C_{Fld} (mg/L))			
Central	0.003	mg/L	APPL.TYPDR×1000
Lower	0.001		APPL.LOWDR×1000
Upper	0.021		APPL.HI_DR×1000
Concentrations in ambient water (C_{Wat}): $C_{Fld} \times VS_{(Liters)} \div VL$			
Central	2.27e-06	mg/L	
Lower	7.57e-07		
Upper	1.59e-05		
Bioconcentration factor ($BCF_{(L/kg\ fish)}$)	2000	L/kg fish	CHEM.BCFT
Concentration in fish (C_{Fish}): $C_{Wat} \times BCF$			
Central	0.004542	mg/kg fish	
Lower	0.001514		
Upper	0.031794		
Body weight (W)	70	kg	PUBL.BWM
Amount of fish consumed (A)			
Central	0.77	kg/day	PUBL.FNU
Lower	0.77		PUBL.FNU
Upper	0.77		PUBL.FNU
Dose estimates (D): $C_{Fish} \times A \div W$			
Central	5.00e-05	mg/kg bw	
Lower	1.67e-05		
Upper	3.50e-04		

Worksheet D09a: Consumption of contaminated fish, chronic exposure scenario for recreational fisherman [FishChHHRA01].

Verbal Description: An adult (70 kg male) consumes fish taken from contaminated ambient water for a lifetime. The levels in water are estimated from monitoring data and thus dissipation, degradation and other environmental processes are implicitly considered. As in the chronic drinking water scenario, the concentration in water is calculated as the application rate multiplied by the water contamination rate. The concentration in fish is estimated as the product of the concentration in water and the chronic BCF. The dose is calculated as the product of the concentration in the fish and the amount of fish consumed divided by the body weight.

Parameters/Assumptions		Value	Units	Source/Reference
Application Rates (<i>R</i>)				
	Central	8.75e-07	lb/acre	APPL.Typ
	Lower	8.75e-07		APPL.Low
	Upper	8.75e-07		APPL.Hi
Water Contamination Rate (<i>WCR</i>)				
	Central	5.00e-04	mg/L per lb/acre applied	AMBWAT.AWT
	Lower	3.00e-05		AMBWAT.AWL
	Upper	1.00e-03		AMBWAT.AWU
Concentration in Water (C_{Wat}): $R \times WCR$				
	Central	4.38e-10	mg/L	
	Lower	2.63e-11		
	Upper	8.75e-10		
Bioconcentration factor (<i>BCF</i>)				
		20000	L/kg fish	CHEM.BCFCh
Concentration in fish (C_{Fish}): $C_{Wat} \times BCF$				
	Central	8.75e-06	mg/kg fish	
	Lower	5.25e-07		
	Upper	1.75e-05		
Body weight (<i>W</i>)				
		70	kg	PUBL.BWM
Amount of fish consumed (<i>A</i>)				
	Central	0.01	kg/day	PUBL.FAT
	Lower	0.01		PUBL.FAT
	Upper	0.01		PUBL.FAT
Dose estimates (<i>D</i>): $C_{Fish} \times A \div W$				
	Central	1.25e-09	mg/kg bw/day	
	Lower	7.50e-11		
	Upper	2.50e-09		

Worksheet D09b: Consumption of contaminated fish, chronic exposure scenario for subsistence populations [FishChHHRA02].

Verbal Description: An individual who relies on caught fish as a major source of protein consumes fish taken from contaminated ambient water for a lifetime. The levels in water are estimated from monitoring data and thus dissipation, degradation and other environmental processes are implicitly considered. As in the chronic drinking water scenario, the concentration in water is calculated as the application rate multiplied by the water contamination rate. The concentration in fish is estimated as the product of the concentration in water and the chronic BCF. The dose is calculated as the product of the concentration in the fish and the amount of fish consumed divided by the body weight.

Parameters/Assumptions	Value	Units	Source/Reference
Application Rates (<i>R</i>)			
Central	8.75e-07	lb/acre	APPL.Typ
Lower	8.75e-07		APPL.Low
Upper	8.75e-07		APPL.Hi
Water Contamination Rate (<i>WCR</i>): $C \div R$			
Central	5.00e-04	mg/L per lb/acre applied	AMBWAT.AWT
Lower	3.00e-05		AMBWAT.AWL
Upper	1.00e-03		AMBWAT.AWU
Concentration in Water (<i>C</i>): $R \times WCR$			
Central	4.38e-10	mg/L	
Lower	2.63e-11		
Upper	8.75e-10		
Bioconcentration factor (<i>BCF</i>)	20000	L/kg fish	CHEM.BCFCh
Concentration in fish (<i>C_{Fish}</i>): $C_{\text{Wat}} \times BCF$			
Central	8.75e-06	mg/kg fish	
Lower	5.25e-07		
Upper	1.75e-05		
Body weight (<i>W</i>)	70	kg	PUBL.BWM
Amount of fish consumed (<i>A</i>)			
Central	0.081	kg/day	PUBL.FNT
Lower	0.081		PUBL.FNT
Upper	0.081		PUBL.FNT
Dose estimates (<i>D</i>): $C_{\text{Fish}} \times A \div W$			
Central	1.01e-08	mg/kg bw/day	
Lower	6.08e-10		
Upper	2.03e-08		

SUMMARY TABLES FOR HUMAN HEALTH RISK ASSESSMENT

Worksheet E01: Summary of Worker Exposure Scenarios

Scenario	Dose (mg/kg/day or event)			Exposure Assessment Worksheet
	Central	Lower	Upper	
General Exposures (dose in mg/kg/day)				
Directed ground spray (Backpack)	1.15e-08	3.94e-10	7.00e-08	C01a
Broadcast ground spray (Boom spray)	1.96e-08	5.78e-10	1.32e-07	C01b
Aerial applications	1.29e-08	2.10e-10	7.00e-08	C01c
Accidental/Incidental Exposures (dose in mg/kg/event)				
Immersion of Hands, 1 minute	4.68e-07	4.80e-08	1.05e-05	C02a
Contaminated Gloves, 1 hour	2.81e-05	2.88e-06	6.30e-04	C02b
Spill on hands, 1 hour	6.27e-09	4.50e-10	1.92e-07	C03a
Spill on lower legs, 1 hour	1.54e-08	1.11e-09	4.73e-07	C03b

Worksheet E02: Summary of risk characterization (HQ's¹) for workers.

Acute RfD	0.008	mg/kg/day	Sect. 3.3.3.1
Chronic RfD	0.0008	mg/kg/day	Sect. 3.3.3.1
Cancer risk of 1 in 1 million	6.25e-07	mg/kg/day	Sect. 3.3.3.2
Hazard Quotient Based on Chronic RfD			
Scenario	Central	Lower	Upper
Exposure Assessment Worksheet			
General Exposures [using Chronic RfD]			
Directed ground spray (Backpack)	1e-05	5e-07	9e-05
Broadcast ground spray (Boom spray)	2e-05	7e-07	2e-04
Aerial applications	2e-05	3e-07	9e-05
General Exposures [using 1 in 1 million cancer risk dose]			
Directed ground spray (Backpack)	2e-02	6e-04	1e-01
Broadcast ground spray (Boom spray)	3e-02	9e-04	2e-01
Aerial applications	2e-02	3e-04	1e-01
Accidental/Incidental Exposures [using Acute RfD]			
Hazard Quotient Based on Acute RfD			
Scenario	Central	Lower	Upper
Exposure Assessment Worksheet			
Immersion of Hands, 1 minute	6e-05	6e-06	1e-03
Contaminated Gloves, 1 hour	4e-03	4e-04	8e-02
Spill on hands, 1 hour	8e-07	6e-08	2e-05
Spill on lower legs, 1 hour	2e-06	1e-07	6e-05

¹ Hazard quotient is the level of exposure divided by the RfD then rounded to one significant decimal place or digit. See Worksheet E01 for summary of exposure assessment.

Worksheet E03: Summary of Exposure Scenarios for the General Public

Scenario	Target	Dose (mg/kg/day)			Worksheet
		Central	Lower	Upper	
Acute/Accidental Exposures					
Direct spray, entire body	Child	2.37e-07	1.70e-08	7.25e-06	D01a
Direct spray, lower legs	Woman	2.38e-08	1.71e-09	7.28e-07	D01b
Dermal, contaminated vegetation	Woman	1.08e-08	2.80e-09	2.39e-08	D02
Contaminated fruit	Woman	1.87e-08	1.87e-08	1.39e-07	D03
Contaminated water, spill	Child	1.71e-07	3.47e-08	1.79e-06	D05
Contaminated water, stream	Child	5.92e-09	4.01e-11	2.96e-08	D06
Consumption of fish, general public	Man	1.03e-05	3.42e-06	7.18e-05	D08a
Consumption of fish, subsistence populations	Man	5.00e-05	1.67e-05	3.50e-04	D08b
Chronic/Longer Term Exposures					
Contaminated fruit	Woman	7.26e-10	1.68e-10	6.41e-09	D04
Consumption of water	Man	1.25e-11	5.25e-13	3.00e-11	D07
Consumption of fish, general public	Man	1.25e-09	7.50e-11	2.50e-09	D09a
Consumption of fish, subsistence populations	Man	1.01e-08	6.08e-10	2.03e-08	D09b

Worksheet E04: Summary of risk characterization (HQ's¹) for the general public ¹.

Chronic RfD		0.0008	mg/kg/day	Sect. 3.3.3.	
Cancer risk, 1 in 1 million		6.25e-07	mg/kg/day	Sect. 3.3.3.	
Acute RfD		0.008	mg/kg/day	Sect. 3.3.3.	
Scenario	Target	Hazard Quotient			Worksheet
		Central	Lower	Upper	
Acute/Accidental Exposures					
Direct spray, entire body	Child	3e-05	2e-06	9e-04	D01a
Direct spray, lower legs	Woman	3e-06	2e-07	9e-05	D01b
Dermal, contaminated vegetation	Woman	1e-06	3e-07	3e-06	D02
Contaminated fruit	Woman	2e-06	2e-06	2e-05	D03
Contaminated water, spill	Child	2e-05	4e-06	2e-04	D05
Contaminated water, stream	Child	7e-07	5e-09	4e-06	D06
Consumption of fish, general public	Man	1e-03	4e-04	9e-03	D08a
Consumption of fish, subsistence populations	Man	6e-03	2e-03	4e-02	D08b
Chronic/Longer Term Exposures based on chronic RfD					
Contaminated fruit	Woman	9e-07	2e-07	8e-06	D04
Consumption of water	Man	2e-08	7e-10	4e-08	D07
Consumption of fish, general public	Man	2e-06	9e-08	3e-06	D09a
Consumption of fish, subsistence populations	Man	1e-05	8e-07	3e-05	D09b
Chronic/Longer Term Exposures based on cancer risk of 1 in 1 million					
Contaminated fruit	Woman	1e-03	3e-04	1e-02	D04
Consumption of water	Man	2e-05	8e-07	5e-05	D07
Consumption of fish, general public	Man	2e-03	1e-04	4e-03	D09a
Consumption of fish, subsistence populations	Man	2e-02	1e-03	3e-02	D09b

¹ The hazard quotients are the level of exposure divided by the RfD then rounded to one or two significant decimal places or digits. Hazard quotients >1 and ≤2 are shown to two significant digits. All others are rounded to one significant decimal place or integer. All hazard quotients that are below the level of concern – i.e., a hazard quotient below unity – are expressed in scientific notation. All hazard quotients greater than unity are expressed in fixed point decimal notation and highlighted with a shaded background.

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