EPA United States Environmental Protection Agency

Waste and Cleanup Risk Assessment

Preliminary Remediation Goals for Radionuclides (PRG)

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PRG User's Guide

PDF of User's Guide.

Contents

Welcome to the EPA's "Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites" (PRG) user's guide. Here you will find descriptions, equations and default exposure parameters used to calculate the risk-based PRGs. Additional guidance is also provided on sources of parameters and proper PRG use. It is suggested that users read the PRG FAQ page before proceeding. The user guide is extensive so please use the "Open All Sections" and "Close All Sections" links below as needed. Individual sections can be opened and closed by clicking on the section titles. Before proceeding through the user's guide please read the Disclaimer.

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5. Recommended Default Exposure Parameters

Table 1 presents the definitions of the variables and their default values. The PRG default values and exposure models are consistent with the Dose Compliance Concentrations for Radionuclides (DCC) calculator. Both the PRG and DCC calculator default values are consistent with the Regional Screening Levels for Chemical Contaminants at Superfund Sites (RSL) calculator where the same pathways are addressed (e.g., ingestion and inhalation) and are analogous where pathways are similar (e.g., dermal and external exposure). This calculator, the DCC, and the RSL, all follow the recommendations in the OSWER Directive concerning use of exposure parameters from the 2011 Exposure Factors Handbook. Any alternative values or assumptions used in remedy evaluation or selection on a CERCLA site should be presented with supporting rationale in Administrative Records.

Table 1. Recommended Default Exposure Parameters

Slope Factors			
Symbol	Definition (units)	Default	Reference
$SF_{ext\text{-}15cm}$	Slope Factor - external exposure (risk/yr per pCi/g)	Isotope-specific	ORNL 2014c
$SF_{ext\text{-}1cm}$	Slope Factor - external exposure (risk/yr per pCi/g)	Isotope-specific	ORNL 2014c
$SF_{ext\text{-}5cm}$	Slope Factor - external exposure (risk/yr per pCi/g)	Isotope-specific	ORNL 2014c
$SF_{ext\text{-}gp}$	Slope Factor - external exposure (risk/yr per pCi/cm^2)	Isotope-specific	ORNL 2014c
$SF_{ext\text{-}sv}$	Slope Factor - external exposure (risk/yr per pCi/g)	Isotope-specific	ORNL 2014c
SF_f	Food Ingestion Slope Factor (risk/pCi)	Isotope-specific	ORNL 2014c
SF_i	Slope Factor - inhalation (risk/pCi)	Isotope-specific	ORNL 2014c
SF_{imm}	Slope Factor - immersion (risk/yr per pCi/L)	Isotope-specific	ORNL 2014c
SF_s	Soil Ingestion Slope Factor - population (risk/pCi)	Isotope-specific	ORNL 2014c
SF_{sa}	Soil Ingestion Slope Factor - adult only (risk/pCi)	Isotope-specific	ORNL 2014c
SF_{sub}	Slope Factor - submersion (risk/yr per pCi/cm^3): For use in this tool, ORNL 2014c units were converted to (risk/yr per pCi/m^3)	Isotope-specific	ORNL 2014c
SF_w	Water Ingestion Slope Factor (risk/pCi)	Isotope-specific	ORNL 2014c

Dose and Decay Constant Variables			
Symbol	Definition (units)	Default	Reference
t_{cw}	Time - construction worker (years)	1	U.S. EPA 2002 Exhibit 5-1
t_{far}	Time - farmer (years)	40	U.S. EPA 2005 (pg. C-24/C-26)
t_{iw}	Time - indoor worker (years)	25	U.S. EPA 1991a (pg. 15)
t_{ow}	Time - outdoor worker (years)	25	U.S. EPA 1991a (pg. 15)
TR	Target Risk	1×10^{-6}	U.S. EPA 1991b
t_{rec}	Time - recreator (years)	site-specific	site-specific
t_{res}	Time - resident (years)	26	U.S. EPA 2011a, Table 16-108; 90th percentile or current residence time.
t_{w}	Time - worker (years)	25	U.S. EPA 1991a (pg. 15)
λ	decay constant = 0.693/half-life ($year^{-1}$) where 0.693 = ln(2)	Isotope-specific	Developed for Radionuclide Soil Screening calculator
Miscellaneous Variables			
Symbol	Definition (units)	Default	Reference
$ACF_{ext-15cm}$	Area Correction Factor - 15cm (unitless)	Isotope-specific	ORNL 2014a
$ACF_{ext-1cm}$	Area Correction Factor - 1cm (unitless)	Isotope-specific	ORNL 2014a
$ACF_{ext-5cm}$	Area Correction Factor - 5cm (unitless)	Isotope-specific	ORNL 2014a
ACF_{ext-gp}	Area Correction Factor - ground plane (unitless)	Isotope-specific	ORNL 2014a
ACF_{ext-sv}	Area Correction Factor - soil volume (unitless)	Isotope-specific	ORNL 2014a
$CF_{far-beef}$	Beef Contaminated Fraction - farmer (unitless)	1	Developed for Radionuclide Soil Screening calculator
$CF_{far-dairy}$	Dairy Contaminated Fraction - farmer (unitless)	1	Developed for Radionuclide Soil Screening calculator
$CF_{far-egg}$	Egg Contaminated Fraction - Farmer (unitless)	1	Developed for Radionuclide Soil Screening calculator
$CF_{far-fish}$	Fish Contaminated Fraction - farmer (unitless)	1	Developed for Radionuclide Soil Screening calculator
$CF_{far-goat}$	Goat Contaminated Fraction - Farmer (unitless)	1	Developed for Radionuclide Soil Screening calculator
$CF_{far-goat-milk}$	Goat Milk Contaminated Fraction - Farmer (unitless)	1	Developed for Radionuclide Soil Screening calculator
$CF_{far-poultry}$	Poultry Contaminated Fraction - farmer (unitless)	1	Developed for Radionuclide Soil Screening calculator
$CF_{far-produce}$	Produce Contaminated Fraction - farmer (unitless)	1	U.S. EPA 2011, U.S. EPA 2005
$CF_{far-sheep}$	Sheep Contaminated Fraction - Farmer (unitless)	1	Developed for Radionuclide Soil Screening calculator
$CF_{far-sheep-milk}$	Sheep Milk Contaminated Fraction - Farmer (unitless)	1	Developed for Radionuclide Soil Screening calculator
$CF_{far-swine}$	Swine Contaminated Fraction - farmer (unitless)	1	Developed for Radionuclide Soil Screening calculator
$CF_{res-produce}$	Produce Contaminated Fraction - resident (unitless)	1	U.S. EPA 2011, U.S. EPA 2005
GSF_{a}	Gamma Shielding Factor - Air (unitless)	1	Developed for Radionuclide Soil Screening calculator
GSF_{b}	Gamma Shielding Factor - building (unitless)	$GSF_{i} \times GSF_{o}$	Developed for Radionuclide Soil Screening calculator
GSF_{i}	Gamma Shielding Factor - Indoor (unitless)	0.4	U.S. EPA 2000a. (pg. 2-22). U.S. EPA 2000b. (pg. 2-18)
$GSF_{o-ext-15cm}$	Gamma Shielding Factor - 15cm (unitless)	Isotope-specific	ORNL 2014b
$GSF_{o-ext-1cm}$	Gamma Shielding Factor - 1cm (unitless)	Isotope-specific	ORNL 2014b
$GSF_{o-ext-5cm}$	Gamma Shielding Factor - 5cm (unitless)	Isotope-specific	ORNL 2014b
$GSF_{o-ext-gp}$	Gamma Shielding Factor - ground plane (unitless)	Isotope-specific	ORNL 2014b
$GSF_{o-ext-sv}$	Gamma Shielding Factor - soil volume (unitless)	Isotope-specific	ORNL 2014a
K	Andelman Volatilization Factor (L/m^3)	0.5	U.S. EPA 1991b (pg. 20)
ρ_{m}	Density of milk (kg/L)	1.03	Milk Composition & Synthesis Resource Library
Tissue Transfer Factors and Animal Ingestion Rates of Fodder, Water, and Soil			
Symbol	Definition (units)	Default	Reference
BCF	Fish Transfer Factor (L/kg)	radionuclide-specific	hierarchy selection in Section 2.4.2
Bv_{dry}	Soil to Plant Transfer Factor - dry (pCi/g-dry plant per pCi/g-dry soil)	radionuclide-specific	hierarchy selection in Section 2.4.2
Bv_{wet}	Soil to Plant Transfer Factor - wet (pCi/g-fresh plant per pCi/g-dry soil)	radionuclide-specific	hierarchy selection in Section 2.4.2 climate and soil selection in 2.5.1.2
F	Irrigation Period (unitless)	0.25	Personal communication
f_{p-beef}	Animal On-site Fraction - beef (unitless)	1	Developed for this calculator
$f_{p-dairy}$	Animal On-site Fraction - dairy (unitless)	1	Developed for this calculator
f_{p-goat}	Animal On-site Fraction - goat (unitless)	1	Developed for this calculator

$f_{p\text{-}goat\text{-}milk}$	Animal On-site Fraction - goat milk (unitless)	1	Developed for this calculator
$f_{p\text{-}poultry}$	Animal On-site Fraction - poultry (unitless)	1	Developed for this calculator
$f_{p\text{-}sheep}$	Animal On-site Fraction - sheep (unitless)	1	Developed for this calculator
$f_{p\text{-}sheep\text{-}milk}$	Animal On-site Fraction - sheep milk (unitless)	1	Developed for this calculator
$f_{p\text{-}swine}$	Animal On-site Fraction - swine (unitless)	1	Developed for this calculator
$f_{s\text{-}beef}$	Fraction of Year Animal On Site - beef (unitless)	1	Developed for this calculator
$f_{s\text{-}dairy}$	Fraction of Year Animal On Site - dairy (unitless)	1	Developed for this calculator
$f_{s\text{-}goat}$	Fraction of Year Animal On Site - goat (unitless)	1	Developed for this calculator
$f_{s\text{-}goat\text{-}milk}$	Fraction of Year Animal On Site - goat milk (unitless)	1	Developed for this calculator
$f_{s\text{-}poultry}$	Fraction of Year Animal On Site - poultry (unitless)	1	Developed for this calculator
$f_{s\text{-}sheep}$	Fraction of Year Animal On Site - sheep (unitless)	1	Developed for this calculator
$f_{s\text{-}sheep\text{-}milk}$	Fraction of Year Animal On Site - sheep milk (unitless)	1	Developed for this calculator
$f_{s\text{-}swine}$	Fraction of Year Animal On Site - swine (unitless)	1	Developed for this calculator
I_f	Interception Fraction (unitless)	0.42	Miller, C. W. 1980
I_r	Irrigation Rate (L/m^2)	3.62	Personal communication
Irr_{dep}	aerial deposition from irrigation multiplier	isotope-specific	Calculated
Irr_{res}	resuspension from irrigation multiplier	isotope-specific	Calculated
Irr_{rup}	root uptake from irrigation multiplier	isotope-specific	Calculated
$MLF_{pasture}$	Pasture Plant Mass Loading Factor (g dry soil per g dry plant)	0.25	Hinton, T. G. 1992
$MLF_{produce}$	Produce Plant Mass Loading Factor (g dry soil per g fresh plant)	plant-specific	See section 2.4.3 of this guide for details
P	Area Density for Root Zone (kg/m^2)	240	Hoffman, F. O., R. H. Gardner, and K. F. Eckerman. 1982; Peterson, H. T., Jr. 1983; McKone, T. E. 1994
$Q_{p\text{-}beef}$	Beef Fodder Intake Rate (kg/day)	11.77	U.S. EPA 2005 (pg. B-138)
$Q_{p\text{-}dairy}$	Dairy Fodder Intake Rate (kg/day)	20.3	U.S. EPA 2005 (pg. B-145)
$Q_{p\text{-}goat}$	Goat Fodder Intake Rate (kg/day)	1.27	Lyons et. al. 1999
$Q_{p\text{-}goat\text{-}milk}$	Goat Milk Fodder Intake Rate (kg/day)	1.59	Lyons et. al. 1999 and Tarr
$Q_{p\text{-}poultry}$	Chicken Fodder Intake Rate (kg/day) Duck Fodder Intake Rate (kg/day) Turkey Fodder Intake Rate (kg/day) Goose Fodder Intake Rate (kg/day)	0.2 0.24 0.68 0.33	U.S. EPA 2005 (pg. B-158/164) NRC 1994 NRC 1994 NRC 1994
$Q_{p\text{-}sheep}$	Sheep Fodder Intake Rate (kg/day)	1.75	Lyons et. al. 1999 and OMAFRA
$Q_{p\text{-}sheep\text{-}milk}$	Sheep Milk Fodder Intake Rate (kg/day)	3.15	Lyons et. al. 1999 and OMAFRA
$Q_{p\text{-}swine}$	Swine Fodder Intake Rate (kg/day)	4.7	U.S. EPA 2005 (pg. B-152)
$Q_{s\text{-}beef}$	Beef Soil Intake Rate (kg/day)	0.5	U.S. EPA 2005 (pg. B-139)
$Q_{s\text{-}dairy}$	Dairy Soil Intake Rate (kg/day)	0.4	U.S. EPA 2005 (pg. B-146)
$Q_{s\text{-}goat}$	Goat Soil Intake Rate (kg/day)	0.23	Handbook of Ecotoxicology (Q_s is 18% of Q_p: sheep surrogate used)
$Q_{s\text{-}goat\text{-}milk}$	Goat Milk Soil Intake Rate (kg/day)	0.29	Handbook of Ecotoxicology (Q_s is 18% of Q_p: sheep surrogate used)
$Q_{s\text{-}poultry}$	Chicken Soil Intake Rate (kg/day) Duck Soil Intake Rate (kg/day) Turkey Soil Intake Rate (kg/day) Goose Soil Intake Rate (kg/day)	0.022 0.024 0.068 0.033	U.S. EPA 2005 (pg. B-159/165) NRC 1994 (Q_s is 10% of Q_p) NRC 1994 (Q_s is 10% of Q_p) NRC 1994 (Q_s is 10% of Q_p)
$Q_{s\text{-}sheep}$	Sheep Soil Intake Rate (kg/day)	0.32	Handbook of Ecotoxicology (Q_s is 18% of Q_p)
$Q_{s\text{-}sheep\text{-}milk}$	Sheep Milk Soil Intake Rate (kg/day)	0.57	Handbook of Ecotoxicology (Q_s is 18% of Q_p)
$Q_{s\text{-}swine}$	Swine Soil Intake Rate (kg/day)	0.37	U.S. EPA 2005 (pg. B-153)
$Q_{w\text{-}beef}$	Beef Water Intake Rate (L/day)	53	U.S. EPA 1999a (pg 10-23). U.S. EPA 1997b.
$Q_{w\text{-}dairy}$	Dairy Water Intake Rate (L/day)	92	U.S. EPA 1999a (pg 10-23). U.S. EPA 1997b.
$Q_{w\text{-}goat}$	Goat Water Intake Rate (L/day)	3.81	Tarr
$Q_{w\text{-}goat\text{-}milk}$	Goat Milk Water Intake Rate (L/day)	8.75	Tarr
$Q_{w\text{-}poultry}$	Chicken Water Intake Rate (L/day) Duck Water Intake Rate (L/day) Turkey Water Intake Rate (L/day) Goose Water Intake Rate (L/day)	0.4 0.48 1.36 0.66	U.S. EPA 2005 (pg. B-159/165), NRC 1994 pg.15 (Q_w=2×Q_p) NRC 1994 pg. 15 ($Q_w = 2 \times Q_p$) NRC 1994 pg. 15 ($Q_w = 2 \times Q_p$) NRC 1994 pg. 15 ($Q_w = 2 \times Q_p$)
$Q_{w\text{-}sheep}$	Sheep Water Intake Rate (L/day)	5.25	OMAFRA

$Q_{w\text{-}sheep\text{-}milk}$	Sheep Milk Water Intake Rate (L/day)	10.4	OMAFRA
$Q_{w\text{-}swine}$	Swine Water Intake Rate (L/day)	11.4	NEC, Swine Nutrition Guide (pg. 19). U.S. EPA 1998 (pg B-180)
R_{es}	soil resuspension multiplier (g dry soil per g fresh plant)	=MLF (pasture or produce)	Hinton 1992
R_{upp}	dry root uptake for pasture multiplier (pCi/g-dry plant per pCi/g-dry soil)	radionuclide-specific (=Bv_{dry})	hierarchy selection in Section 2.4.2
R_{upv}	wet root uptake for produce multiplier (pCi/g-fresh plant per pCi/g-dry soil)	radionuclide-specific (=Bv_{wet})	hierarchy selection in Section 2.4.2
T	Translocation Factor (unitless)	1	NCRP 1984
t_b	Long Term Deposition and Buildup (day)	10950	NCRP 1985
TF_{beef}	Beef Transfer Factor (day/kg)	radionuclide-specific	hierarchy selection in Section 2.4.2
TF_{dairy}	Dairy Transfer Factor (day/L)	radionuclide-specific	hierarchy selection in Section 2.4.2
TF_{egg}	Egg Transfer Factor (day/kg)	radionuclide-specific	hierarchy selection in Section 2.4.2
TF_{goat}	Goat Transfer Factor (day/kg)	radionuclide-specific	hierarchy selection in Section 2.4.2
$TF_{goat\text{-}milk}$	Goat Milk Transfer Factor (day/L)	radionuclide-specific	hierarchy selection in Section 2.4.2
$TF_{poultry}$	Poultry Transfer Factor (day/kg)	radionuclide-specific	hierarchy selection in Section 2.4.2
TF_{sheep}	Sheep Transfer Factor (day/kg)	radionuclide-specific	hierarchy selection in Section 2.4.2
$TF_{sheep\text{-}milk}$	Sheep Milk Transfer Factor (day/L)	radionuclide-specific	hierarchy selection in Section 2.4.2
TF_{swine}	Swine Transfer Factor (day/kg)	radionuclide-specific	hierarchy selection in Section 2.4.2
t_v	Above Ground Exposure Time (day)	60	NCRP 1985
t_w	Weathering Half-life (day)	14	NCRP 1989
Y_v	Plant Yield - wet (kg/m^2)	2	NCRP 1985
λ_B	Effective Rate of Removal from Soil (1/day)	$\lambda_{HL} + \lambda_i$	NCRP 1989
λ_E	Effective Rate of Removal from Produce (1/day)	$\lambda_i + (0.693/t_w)$	NCRP 1989
λ_{HL}	Rate of removal from soil by harvesting or leaching (1/day)	0.000027	NCRP 1989
λ_i	decay of parent or daughter products (1/day)	0.693/HL (days)	NCRP 1989

Inhalation, Ingestion, and Consumption Rates

Symbol	Definition (units)	Default	Reference
$DFA_{rec\text{-}adj}$	Recreator Immersion Factor - age-adjusted (hours)	site-specific	U.S. EPA 1991a (pg. 15)
$IFA_{far\text{-}adj}$	Farmer Inhalation Fraction - age-adjusted (m^3)	259,000	Calculated using the age-adjusted intake factors equation.
$IFA_{rec\text{-}adj}$	Recreator Inhalation Fraction - age-adjusted (m^3)	site-specific	Calculated using the age-adjusted intake factors equation.
$IFA_{res\text{-}adj}$	Resident Inhalation Rate - age-adjusted (m^3)	161,100	Calculated using the age-adjusted intake factors equation.
$IFB_{far\text{-}adj}$	Farmer Beef Ingestion Fraction - age-adjusted (g)	2,098,950	Calculated using the aged adjusted intake factors equation
$IFD_{far\text{-}adj}$	Farmer Dairy Ingestion Fraction - age-adjusted (g)	10,138,030	Calculated using the aged adjusted intake factors equation
$IFE_{far\text{-}adj}$	Farmer Egg Ingestion Rate - age-adjusted (g)	775,810	Calculated using the aged adjusted intake factors equation
$IF_{far\text{-}adj}$	Farmer Produce Ingestion Fraction - age-adjusted (g)	plant-specific	Calculated using the aged adjusted intake factors equation
$IFFI_{far\text{-}adj}$	Farmer Fish Ingestion Fraction - age-adjusted (g)	10,018,960	Calculated using the aged adjusted intake factors equation
$IFP_{far\text{-}adj}$	Farmer Poultry Ingestion Fraction - age-adjusted (g)	1,376,550	Calculated using the aged adjusted intake factors equation
$IF_{res\text{-}adj}$	Resident Produce Ingestion Fraction - age-adjusted (g)	plant-specific	Calculated using the aged adjusted intake factors equation
$IFS_{far\text{-}adj}$	Farmer Soil Ingestion Fraction - age-adjusted (mg)	1,610,000	Calculated using the age-adjusted intake factors equation.
$IFS_{rec\text{-}adj}$	Recreator Ingestion Fraction - age-adjusted (mg)	site-specific	Calculated using the age-adjusted intake factors equation.
$IFS_{res\text{-}adj}$	Resident Ingestion Fraction - age-adjusted (mg)	1,120,000	Calculated using the age-adjusted intake factors equation.
$IFSW_{far\text{-}adj}$	Farmer Swine Ingestion Fraction - age-adjusted (g)	1,171,520	Calculated using the aged adjusted intake factors equation
$IFW_{rec\text{-}adj}$	Recreator Surface Water Ingestion Fraction - age-adjusted (L)	site-specific	Calculated using the age-adjusted intake factors equation.
$IFW_{res\text{-}adj}$	Resident Tapwater Ingestion Rate - age-adjusted (L)	19,138	Calculated using the age-adjusted intake factors equation.
IRA_{cw}	Construction Worker Inhalation Rate (m^3/day; based on a rate of 2.5m^3/hour for 24 hours)	60	U.S. EPA 1997a (pg. 5-11)
$IRA_{far\text{-}a}$	Soil Inhalation Rate - adult farmer(m^3/day)	20	U.S. EPA 1991a (pg. 15)

IRA_{far-c}	Farmer Inhalation Rate - child (m^3/day)	10	U.S. EPA 1997a (pg. 5-11)
IRA_{iw}	Indoor Worker Inhalation Rate (m^3; based on a rate of 2.5m^3/hour for 24 hours)	60	U.S. EPA 1997a (pg. 5-11)
IRA_{ow}	Outdoor Worker Inhalation Rate (m^3/day; based on a rate of 2.5m^3/hour for 24 hours)	60	U.S. EPA 1997a (pg. 5-11)
IRA_{rec-a}	Recreator Inhalation Rate - adult (m^3/day)	20	U.S. EPA 1991a (pg. 15)
IRA_{rec-c}	Recreator Inhalation Rate - child (m^3/day)	10	U.S. EPA 1997a (pg. 5-11)
IRA_{res-a}	Resident Inhalation Rate - adult (m^3/day)	20	U.S. EPA 1991a (pg. 15)
IRA_{res-c}	Resident Inhalation Rate - child (m^3/day)	10	U.S. EPA 1997a (pg. 5-11)
IRA_{w}	Composite Worker Inhalation Rate (m^3/day; based on a rate of 2.5m^3/hour for 24 hours)	60	U.S. EPA 1997a (pg. 5-11)
IRB_{far-a}	Farmer Beef Ingestion Rate - adult (g/day)	165.3	U.S. EPA 2011 (Table 13-33)
IRB_{far-c}	Farmer Beef Ingestion Rate - child (g/day)	62.8	U.S. EPA 2011 (Table 13-33)
IRD_{far-a}	Farmer Dairy Ingestion Rate - adult (g/day)	676.4	U.S. EPA 2011 (Table 13-25)
IRD_{far-c}	Farmer Dairy Ingestion Rate - child (g/day)	994.7	U.S. EPA 2011 (Table 13-25)
IRE_{far-a}	Farmer Egg Ingestion Rate - adult (g/day)	59.6	U.S. EPA 2011 (Table 13-40)
IRE_{far-c}	Farmer Egg Ingestion Rate - child (g/day)	31.7	U.S. EPA 2011 (Table 13-40)
IR_{far-a}	Farmer Produce Ingestion Rate - adult (g/day)	plant-specific	U.S. EPA 2011 (Table 13-10)
IR_{far-c}	Farmer Produce Ingestion Rate - child (g/day)	plant-specific	U.S. EPA 2011 (Table 13-10)
$IRFI_{far-a}$	Farmer Fish Ingestion Rate - adult (g/day)	831.8	U.S. EPA 2011 (Table 13-20)
$IRFI_{far-c}$	Farmer Fish Ingestion Rate - child (g/day)	57.4	U.S. EPA 2011 (Table 13-20)
IRF_{res}	Resident Fish Ingestion Rate (g/day)	54	U.S. EPA 1991a (page 15)
IRP_{far-a}	Farmer Poultry Ingestion Rate - adult (g/day)	107.4	U.S. EPA 2011 (Table 13-52)
IRP_{far-c}	Farmer Poultry Ingestion Rate - child (g/day)	46.9	U.S. EPA 2011 (Table 13-52)
IR_{res-a}	Resident Produce Ingestion Rate - adult (g/day)	plant-specific	U.S. EPA 2011 (Table 13-10)
IR_{res-c}	Resident Produce Ingestion Rate - child (g/day)	plant-specific	U.S. EPA 2011 (Table 13-10)
IRS_{cw}	Construction Worker Soil Ingestion Rate (mg/day)	330	
IRS_{far-a}	Farmer Soil Ingestion Rate - adult (mg/day)	100	U.S. EPA 1991a (pg. 15)
IRS_{far-c}	Farmer Soil Ingestion Rate - child (mg/day)	200	U.S. EPA 1991a (pg. 15)
IRS_{iw}	Indoor Worker Soil Ingestion Rate (mg/day)	50	U.S. EPA 2001 (pg. 4-3)
IRS_{ow}	Outdoor Worker Soil Ingestion Rate (mg/day)	100	U.S. EPA 1991a (pg. 15)
IRS_{rec-a}	Recreator Soil Ingestion Rate - adult (mg/day)	100	U.S. EPA 1991a (pg. 15)
IRS_{rec-c}	Recreator Soil Ingestion Rate - child (mg/day)	200	U.S. EPA 1991a (pg. 15)
IRS_{res-a}	Resident Soil Ingestion Rate - adult (mg/day)	100	U.S. EPA 1991a (pg. 15)
IRS_{res-c}	Resident Soil Ingestion Rate - child (mg/day)	200	U.S. EPA 1991a (pg. 15)
IRS_{w}	Composite Worker Soil Ingestion Rate (mg/day)	100	U.S. EPA 1991a (pg. 15)
$IRSW_{far-a}$	Farmer Swine Ingestion Rate - adult (g/day)	92.5	U.S. EPA 2011 (Table 13-51)
$IRSW_{far-c}$	Farmer Swine Ingestion Rate - child (g/day)	33.7	U.S. EPA 2011 (Table 13-51)
IRW_{rec-a}	Recreator Surface Water Ingestion Rate - adult (L/hour)	0.071	Adult upper percentile from Table 3.5 of EFH 2011
IRW_{rec-c}	Recreator Surface Water Ingestion Rate - child (L/hour)	0.12	Child upper percentile from Table 3.5 of EFH 2011
IRW_{res-a}	Resident Tapwater Ingestion - adult (L/day)	2.5	U.S. EPA 2011a, Tables 3-15 and 3-33; weighted average of 90th percentile consumer-only ingestion of drinking water (birth to <6 years)
IRW_{res-c}	Resident Tapwater Ingestion - child (L/day)	0.78	U.S. EPA 2011a, Tables 3-15 and 3-33; weighted average of 90th percentile consumer-only ingestion of drinking water (birth to <6 years)
Exposure Frequency, Exposure Duration, and Exposure Time Variables			
Symbol ▼	Definition (units)	Default	Reference
DW_{cw}	Construction Worker Exposure Frequency (days/week)	5	U.S. EPA 2002 Exhibit 5-1
ED_{cw}	Construction Worker Exposure Duration (years)	1	U.S. EPA 2002 Exhibit 5-1
ED_{far}	Farmer Exposure Duration (years)	40	U.S. EPA 2005 (Table 6-3)
ED_{far-a}	Farmer Exposure Duration - adult (years)	34	U.S. EPA 1994a
ED_{far-c}	Farmer Exposure Duration - child (years)	6	U.S. EPA 2005 (Table 6-3)

ED_{iw}	Indoor Worker Exposure Duration (years)	25	U.S. EPA 1991a (pg. 15)
ED_{ow}	Outdoor Worker Exposure Duration (years)	25	U.S. EPA 1991a (pg. 15)
ED_{rec}	Recreator Exposure Duration (years)	site-specific	U.S. EPA 2011a, Table 16-108; 90th percentile or current residence time.
ED_{rec-a}	Recreator Exposure Duration - adult (years)	site-specific	-
ED_{rec-c}	Recreator Exposure Duration - child (years)	site-specific	U.S. EPA 1991a, Pages 6 and 15
ED_{res}	Resident Exposure Duration (years)	26	U.S. EPA 2011a, Table 16-108; 90th percentile or current residence time.
ED_{res-a}	Resident Exposure Duration - adult (years)	20	ED_{res} (26 years) - ED_{res-c} (6 years)
ED_{res-c}	Resident Exposure Duration - child (years)	6	U.S. EPA 1991a, Pages 6 and 15
ED_{w}	Composite Exposure Duration (years)	25	U.S. EPA 1991a (pg. 15)
EF_{cw}	Construction Worker Exposure Frequency (days/year)	250	U.S. EPA 2002 Exhibit 5-1
EF_{far}	Farmer Exposure Frequency (days/year)	350	U.S. EPA 1991a (pg. 15)
EF_{iw}	Indoor Worker Exposure Frequency (days/year)	250	U.S. EPA 1991a (pg. 15)
EF_{ow}	Outdoor Worker Exposure Frequency (days/year)	225	U.S. EPA 1991a (pg. 15)
EF_{rec}	Recreator Exposure Frequency - (days/year)	site-specific	U.S. EPA 1991a (pg. 15)
EF_{rec-a}	Recreator Exposure Frequency - adult (days/year)	site-specific	U.S. EPA 1991a (pg. 15)
EF_{rec-c}	Recreator Exposure Frequency - child (days/year)	site-specific	U.S. EPA 1991a (pg. 15)
EF_{res}	Resident Exposure Frequency - (days/year)	350	U.S. EPA 1991a (pg. 15)
EF_{res-a}	Resident Exposure Frequency - adult (days/year)	350	U.S. EPA 1991a (pg. 15)
EF_{res-c}	Resident Exposure Frequency - child (days/year)	350	U.S. EPA 1991a (pg. 15)
EF_{w}	Composite Worker Exposure Frequency (days/year)	250	U.S. EPA 1991a (pg. 15)
ET_{cw}	Construction Worker Exposure Time (hours/day)	8	Eight Hours per 24 hour Day
ET_{far}	Farmer Exposure Time (hours/day)	24	24 Hours per 24 hour Day
ET_{far-a}	Farmer Exposure Time - away (hours/day)	1.83	U.S. EPA 2011 (Tables 16-20 and 16-24 total of time in vehicles, near vehicles and outdoors other than near residence 25th%)
ET_{far-i}	Farmer Exposure Time - indoor (hours/day)	10.0	1440 hrs/day - (ET_{f-o} + ET_{f-a})
ET_{far-o}	Farmer Exposure Time - outdoor (hours/day)	12.167	U.S. EPA 2011 (Table 16-20 95th%))
ET_{iw}	Indoor Worker Exposure Time (hours/day)	8	Eight Hours per 24 hour Day
ET_{ow}	Outdoor Worker Exposure Time (hours/day)	8	Eight Hours per 24 hour Day
ET_{rec}	Recreator Exposure Time (hours/day)	site-specific	
ET_{rec-a}	Recreator Exposure Time - adult (hours/day)	site-specific	
ET_{rec-c}	Recreator Exposure Time - child (hours/day)	site-specific	
ET_{res}	Resident Exposure Time (hours/day)	24	24 Hours per 24 hour Day
ET_{res-i}	Resident Exposure Time - indoor (hours/day)	16.416	U.S. EPA 2011 (Table 16-16 50th%)
ET_{res-o}	Resident Exposure Time - outdoor (hours/day)	1.752	U.S. EPA 2011 (Table 16-20 50th%))
ET_{w}	Composite Worker Exposure Time (hours/day)	8	Eight Hours per 24 hour Day
EV_{rec-a}	Number of bathing events per day - adult recreator (events/day)	site-specific	-
EV_{rec-c}	Number of bathing events per day - child recreator (events/day)	site-specific	U.S. EPA 1991a, Pages 6 and 15
EV_{res-a}	Number of bathing events per day - adult resident (events/day)	1	
EV_{res-c}	Number of bathing events per day - child resident (events/day)	1	
EW_{cw}	Construction Worker Exposure Frequency (weeks/year)	50	U.S. EPA 2002 Exhibit 5-1

Soil to Groundwater SSL Factor Variables

Symbol ▼	Definition (units)	Default	Reference
C_w	Target soil leachate concentration (pCi/L)	nonzero MCL or RSL × DAF	U.S. EPA. 2002 Equation 4-14
d	mixing zone depth (m)	site-specific	U.S. EPA. 2002 Equation 4-12
d_a	aquifer thickness (m)	site-specific	U.S. EPA. 2002 Equation 4-10
DAF	Dilution attenuation factor (unitless)	1 (or site-specific)	U.S. EPA. 2002 Equation 4-11
d_s	depth of source (m)	site-specific	U.S. EPA. 2002 Equation 4-10
ED_{gw}	Exposure duration	70	U.S. EPA. 2002 Equation 4-14
I	Infiltration Rate (m/year)	0.18	U.S. EPA. 2002 Equation 4-11

i	hydraulic gradient (m/m)	site-specific	U.S. EPA. 2002 Equation 4-11
K	aquifer hydraulic conductivity (m/year)	site-specific	U.S. EPA. 2002 Equation 4-11
K_d	soil-water partition coefficient (L/kg)	= K_{oc}*f_{oc} for organics	U.S. EPA. 2002 Equation 4-10
L	source length parallel to ground water flow (m)	site-specific	U.S. EPA. 2002 Equation 4-11
n	total soil porosity(L_{pore}/L_{soil})	= 1-(ρ_b/ρ_s)	U.S. EPA. 2002 Equation 4-10
θ_a	air-filled soil porosity (L_{air}/L_{soil})	= n-θ_w	U.S. EPA. 2002 Equation 4-10
θ_w	water-filled soil porosity (L_{water}/L_{soil})	0.3	U.S. EPA. 2002 Equation 4-10
ρ_b	dry soil bulk density (kg/L)	1.5	U.S. EPA. 2002 Equation 4-10
ρ_s	soil particle density (Kg/L)	2.65	U.S. EPA. 2002 Equation 4-10
Wind Particulate Emission Factor Variables			
Symbol ▼	Definition (units)	Default	Reference
A	Dispersion constant unitless	PEF and region-specific	U.S. EPA 2002 Exhibit D-2
A_s	Areal extent of the site or contamination (acres)	0.5 (range 0.5 to 500)	U.S. EPA 2002 Exhibit D-2
B	Dispersion constant unitless	PEF and region-specific	U.S. EPA 2002 Exhibit D-2
C	Dispersion constant unitless	PEF and region-specific	U.S. EPA 2002 Exhibit D-2
F(x)	Function Dependent on 0.886 × (U_t/U_m) (unitless)	0.194	U.S. EPA. 1996, Appendix D Table 2
PEF_w	Particulate Emission Factor - Minneapolis (m^3/kg)	1.36 x 10^9(region-specific)	U.S. EPA 2002 Exhibit D-2
Q/C_{wind}	Inverse of the Mean Concentration at the Center of a 0.5-Acre-Square Source (g/m^2-s per kg/m^3)	93.77 (region-specific)	U.S. EPA 2002 Exhibit D-2
U_m	Mean Annual Wind Speed (m/s)	4.69	U.S. EPA. 1996, Appendix D Table 2
U_t	Equivalent Threshold Value of Wind Speed at 7m (m/s)	11.32	U.S. EPA. 1996, Appendix D Table 2
V	Fraction of Vegetative Cover (unitless)	0.5	U.S. EPA. 2002 Equation 4-5
Mechanical Particulate Emission Factor Variables from Standard Unpaved Road Vehicle Traffic			
Symbol ▼	Definition (units)	Default	Reference
A	Dispersion constant unitless	12.9351	U.S. EPA 2002 Equation 5-6
A_R	Surface area of contaminated road segment (m^2)	($A_R = L_R$ x W_R x 0.092903m^2 /ft^2)	U.S. EPA 2002 Equation 5-5
A_s	Areal extent of site surface soil contamination (acres)	0.5 (range 0.5 to 500)	U.S. EPA 2002 Equation 5-6
B	Dispersion constant unitless	5.7383	U.S. EPA 2002 Equation 5-6
C	Dispersion constant unitless	71.7711	U.S. EPA 2002 Equation 5-6
F_D	Dispersion correction factor (unitless)	0.185	U.S. EPA 2002 Equation E-16
L_R	Length of road segment (ft)	Site-specific	U.S. EPA 2002 Equation 5-5
p	Number of days with at least 0.01 inches of precipitation (days/year)	Site-specific	U.S. EPA 2002 Exhibit 5-2
PEF_{sc}	Particulate Emission Factor - subchronic (m^3/kg)	(site-specific)	U.S. EPA 2002 Equation 5-5
Q/C_{sr}	Inverse of the ratio of the 1-h geometric mean concentration to the emission flux along a straight road segment bisecting a square site (g/m^2-s per kg/m^3)	23.02 (for 0.5 acre site)	U.S. EPA 2002 Equation 5-5
T	Total time over which construction occurs (s)	site-specific	U.S. EPA 2002 Equation 5-5
W	Mean vehicle weight (tons)	(number of cars x tons/car + number of trucks x tons/truck) / total vehicles)	U.S. EPA 2002 Equation 5-5
W_R	Width of road segment (ft)	20	U.S. EPA 2002 Equation E-18
∑VKT	Sum of fleet vehicle kilometers traveled during the exposure duration (km)	∑VKT = total vehicles x distance (km/day) x frequency (weeks/year) x (days/year)	U.S. EPA 2002 Equation 5-5
Mechanical Particulate Emission Factor Variables from Other Construction Activities			
Symbol ▼	Definition (units)	Default	Reference
0.35	PM_{10} particle size multiplier (unitless)	0.35	U.S. EPA 2002 Equation E-21
0.60	PM_{10} scaling factor (unitless)	0.60	U.S. EPA 2002 Equation E-23
0.75	PM_{10} scaling factor (unitless)	0.75	U.S. EPA 2002 Equation E-22
A	Dispersion constant unitless	2.4538	U.S. EPA 2002 Equation E-15
$A_{c\text{-}doz}$	Areal extent of dozing (acres)	Site-specific	Necessary to solve $\sum VKT_{doz}$ in U.S. EPA 2002 Equation E-22
$A_{c\text{-}grade}$	Areal extent of grading (acres)	Site-specific	Necessary to solve $\sum VKT_{grade}$ in U.S. EPA 2002 Equation E-23
$A_{c\text{-}till}$	Areal extent of tilling (acres)	Site-specific	U.S. EPA 2002 Equation E-24
A_{excav}	Areal extent of excavation (m^2)	(range 0.5 to 500)	U.S. EPA 2002 Equation E-21
A_s	Areal extent of site surface soil contamination (acres)	(range 0.5 to 500)	U.S. EPA 2002 Equation E-15

A_{surf}	Areal extent of site surface soil contamination (m^2)	(range 0.5 to 500)	U.S. EPA 2002 Equation E-20
B	Dispersion constant unitless	17.5660	U.S. EPA 2002 Equation E-15
B_d	Dozer blade length (m)	Site-specific	U.S. EPA 2002 Page E-28
B_g	Grader blade length (m)	Site-specific	U.S. EPA 2002 Page E-28
C	Dispersion constant unitless	189.0426	U.S. EPA 2002 Equation E-15
d_{excav}	Average depth of excavation (m)	Site-specific	U.S. EPA 2002 Equation E-21
ED	Exposure duration (years)	Site-specific	U.S. EPA 2002 Equation E-20
F(x)	Function Dependent on 0.886 × (U_t/U_m) (unitless)	0.194	U.S. EPA. 1996, Appendix D Table 2
F_D	Dispersion correction factor (unitless)	Site-specific	U.S. EPA 2002 Equation E-16
J'_T (g/m^2-s)	Total time-averaged PM_{10} unit emission flux for construction activities other than traffic on unpaved roads	Site-specific	U.S. EPA 2002 Equation E-25
M_{doz}	Unit mass emitted from dozing operations (g)	site-specific	U.S. EPA 2002 Equation E-22
M_{excav}	Unit mass emitted from excavation soil dumping (g)	site-specific	U.S. EPA 2002 Equation E-21
M_{grade}	Unit mass emitted from grading operations (g)	site-specific	U.S. EPA 2002 Equation E-23
$M_{m\text{-}doz}$	Gravimetric soil moisture content (%)	7.9 (mean value for overburden)	U.S. EPA 2002 Equation E-22
$M_{m\text{-}excav}$	Gravimetric soil moisture content (%)	12 (mean value for municipal landfill cover)	U.S. EPA 2002 Equation E-21
M^{PC}_{wind}	Unit mass emitted from wind erosion (g)	site-specific	U.S. EPA 2002 Equation E-20
M_{till}	Unit mass emitted from tilling operations (g)	site-specific	U.S. EPA 2002 Equation E-24
$N_{A\text{-}doz}$	Number of times site is dozed (unitless)	Site-specific	U.S. EPA 2002 Equation E-22
$N_{A\text{-}dump}$	Number of times soil is dumped (unitless)	2	U.S. EPA 2002 Equation E-21
$N_{A\text{-}grade}$	Number of times site is graded (unitless)	Site-specific	U.S. EPA 2002 Equation E-23
$N_{A\text{-}till}$	Number of times soil is tilled (unitless)	2	U.S. EPA 2002 Equation E-24
PEF'_{sc}	Particulate Emission Factor - subchronic (m^3/kg)	(site-specific)	U.S. EPA 2002 Equation E-26
Q/C_{sa}	Inverse of the ratio of the 1-h. geometric mean air concentration and the emission flux at the center of the square emission source (g/m^2-s per kg/m^3)	Site-specific	U.S. EPA 2002 Equation E-15
s_{doz}	Soil silt content (%)	6.9	U.S. EPA 2002 Equation E-22
S_{doz}	Average dozing speed (kph)	11.4 (mean value for graders)	U.S. EPA 2002 Equation E-22
S_{grade}	Average grading speed (kph)	11.4 (mean value for graders)	U.S. EPA 2002 Equation E-23
s_{till}	Soil silt content (%)	18	U.S. EPA 2002 Equation E-24
U_m	Mean Annual Wind Speed (m/s)	4.69	U.S. EPA. 1996, Appendix D Table 2
U_t	Equivalent Threshold Value of Wind Speed at 7m (m/s)	11.32	U.S. EPA. 1996, Appendix D Table 2
V	Fraction of Vegetative Cover (unitless)	0	U.S. EPA 2002 Equation E-20
ρ_{soil}	In situ soil density (includes water) (Mg/m^3)	1.68	U.S. EPA 2002 Equation E-21
$\sum VKT_{doz}$	Sum of dozing kilometers traveled (km)	Site-specific	U.S. EPA 2002 Equation E-22
$\sum VKT_{grade}$	Sum of grading kilometers traveled (km)		U.S. EPA 2002 Equation E-23

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