APPENDIX A
EQUATIONS USED IN ANALYSIS

Table A-1.1. Constituent Concentration In Residential Plot Due to Erosion

Adult Resident Exposure Scenario

$$C_R = \frac{SL_{0,F} \times C_0 \times ER}{ks_R \times M_R} + \frac{SL_{B,F} \times C_{B/Surr} \times ER}{M_R \times ks_R} + \frac{Ds_{(1)R}}{ks_R}$$

Parameter	Definition	Central Tendency	High End
C_R	Constituent concentration at residential plot (mg/kg)		
$SL_{0,F}$	Soil load delivered to off-site location for material originating in source area (kg/yr)	Calculated (see Equation A-1.2.)	
$SL_{B,F}$	Soil load delivered to off-site location for material originating in buffer area (kg/yr)	Calculated (see Equation A-1.7.)	
$C_{B/Surr}$	Constituent concentration in buffer and surrounding areas (mg/kg)	Calculated (see Equation A-1.11.)	
$Ds_{(1),R}$	Deposition term for the residential plot (mg/kg.yr)	Calculated (see Equation A-1.24.)	
C_0	Source contaminant concentration (mg/kg)	Chemical-specific	
ks_R	Constituent loss constant from the residential plot (1/yr)	Calculated (see Equation A-1.25.)	
M_R	Mass of soil in mixing depth of residential plot (kg)	Calculated (see Equation A-1.32.)	
ER	Constituent enrichment ratio (unitless)	Organics = 3 Metals = 1	

Description

This equation is used to calculate the mass of constituent deposited onto residential plot as a result of erosion from the source.

Table A-1.2. Soil Load Delivered to Off-Site Location for Material Originating from Source Area

All Exposure Scenarios
$SL_{0,F} = X_{e,S} \; x \; A_S \; x \; (1 - SD_{SB}) \; x \; SF_{0,F}$

Parameter	Definition	Central Tendency	High End
$SL_{0,F}$	Soil load delivered to off-site location for material originating from source area (kg/yr)		
$X_{e,s}$	Unit soil loss from source (kg/m^2-yr)	Calculated (see Table A-1.3.)	
A_S	Area of source (m^2)	Source-specific	
SD_{SB}	Sediment delivery ratio for sub-basin (unitless)	Calculated (see Table A-1.4.)	
$SF_{O,F}$	Scaling factor	Calculated (see Table A-1.6.)	

Description
This equation is used to calculate the load of eroded soil originating from the source that is deposited onto the off-site location of interest.

Table A-1.3. Universal Soil Loss Equation (USLE) for the Source Area

All Exposure Scenarios			
$$X_{e,S} = R_S \ x \ K_S \ x \ LS_S \ x \ C_S \ x \ P_S \ x \ \frac{907.18}{4047}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
$X_{e,S}$	Unit soil loss from the source ($kg/m^2/yr$)		
R_S	USLE rainfall (or erosivity) factor (1/yr)	428	50
K_S	USLE erodibility factor (ton/acre)	0.37	
LS_S	USLE length-slope factor (unitless)	1.5	
C_S	USLE cover management factor (unitless)	0.1	
P_S	USLE supporting practice factor (unitless)	1	
907.18	Conversion factor (kg/ton)		
4047	Conversion factor (m^2/acre)		
Description			
This equation calculates the soil loss rate from the source, using the Universal Soil Loss Equation; the result is used in the soil erosion load equation.			

Table A-1.4. Sediment Delivery Ratio

All Exposure Scenarios

$$SD_{SB} = a \ x \ (A_S + A_{B/Surr} + A_F)^{-b}$$

Parameter	Definition	Central Tendency	High End
SD_{SB}	Sediment delivery ratio for sub-basin (unitless)		
a	Empirical intercept coefficient	Depends on sub-basin area; see table below	
A_S	Area of source (m^2)	Waste management scenario specific	
$A_{B/Surr}$	Area of buffer and surrounding areas (m^2)	Calculated (see Table A-1.5.)	
A_F	Area of off-site location of interest (m^2)	Ag. field = 2,000,000 Residential plot or home garden = 5,100	
b	Empirical slope coefficient	0.125	

Description

This equation calculates the sediment delivery ratio for the sub-basin; the result is used in the soil erosion load equation.

Values for Empirical Intercept Coefficient, a

Sub-basin (A_s+$A_{B/Surr}$+A_F)	"a" coefficient (unitless)
≤ 0.1	2.1
1	1.9
10	1.4
100	1.2
1,000	0.6
1 sq. mile = 2.59×10^6 m^2	

Table A-1.5. Buffer and Surrounding Areas

All Exposure Scenarios			
$A_{B/Surr} = d_b \, x \, \sqrt{A_F} \quad if \quad A_F > A_S$ $A_{B/Surr} = \left(\sqrt{A_F} + d_b\right) x \, \sqrt{A_S} - \sqrt{A_F} \;\; if \;\; A_S \geq A_F \;\; but \;\; \sqrt{A_S} < d_b + \sqrt{A_F}$ $A_{B/Surr} = A_S - A_F \;\; if \;\; A_S > A_F \;\; and \;\; \sqrt{A_S} \geq d_b + \sqrt{A_F}$			
Parameter	**Definition**	**Central Tendency**	**High End**
$A_{B/Surr}$	Area of buffer and surrounding areas (m^2)		
d_b	Distance between source and field (side length of buffer area) (m)	300	75
A_F	Area of off-site location of interest (m^2)	Ag field = 2,000,000 Residential plot or home garden = 5,100	
A_S	Area of source (m^2)	Waste management of scenario-specific	
Description			
This equation calculates the area of the buffer and surrounding areas for each of the different exposure scenarios.			

Table A-1.6. Scaling Factor

All Exposure Scenarios			
$$SF_{0,F} = \frac{A_F}{A_S + A_{B/Surr} + A_F}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
$SF_{O,F}$	Scaling factor		
A_F	Area of off-site location of interest (m^2)	Ag. field = 2,000,000 Residential or home garden = 5,100	
$A_{B/Surr}$	Area of buffer and surrounding area (m^2)	Calculated (see Table A-1.5.)	
A_S	Area of source (m^2)	Waste management scenario-specific	
Description			
This term is used to determine what portion of the total amount of eroded source material available for deposition within the sub-basin will be deposited onto just the off-site location of interest.			

Table A-1.7. Soil Load Delivered to Off-Site Location for Material Originating from Buffer Area

All Exposure Scenarios			
$$SL_{B,F} = X_{e,B} \; x \; A_B \; x \; (1 - SD_{SB}) \; x \; SF_{B,F}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
$SL_{B,F}$	Soil load delivered to off-site location for material originating from buffer area (kg/yr)		
$X_{e,B}$	Unit soil loss from buffer area (kg/m^2-sec)	Calculated (see Table A-1.8.)	
A_B	Area of buffer (m^2)	Calculated (see Table A-1.9.)	
SD_{SB}	Sediment delivery ratio for sub basin (unitless)	Calculated (see Table A-1.4.)	
$SF_{B,F}$	Scaling factor	Calculated (see Table A-1.10.)	
Description			
This equation is used to calculate the load of eroded soil originating from the buffer area that is deposited onto the off-site location of interest.			

Table A-1.8. Universal Soil Loss Equation (USLE) for Buffer Area

All Exposure Scenarios			
$$X_{e,B} = R_B \; x \; K_B \; x \; LS_B \; x \; C_B \; x \; P_B \; x \; \frac{907.18}{4047}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
$X_{e,B}$	Unit soil loss for buffer area (kg/m^2 - yr)		
R_B	USLE rainfall factor (1/yr)	428	50
K_B	USLE erodibility factor (ton/acre)	0.37	
LS_B	USLE length-slope factor (unitless)	1.5	
C_B	USLE cover factor (unitless)	0.1	
P_B	USLE erosion control practice factor (unitless)	1.0	
907.18	Units conversion factor (kg/ton)		
4047	Units conversion factor (m^2/acre)		
Description			
This equation is used to calculate the soil loss rate from the buffer area using the Universal Soil Loss Equation; the result is used in the soil erosion load equation.			

Table A-1.9. Buffer Area

All Exposure Scenarios			
$A_B = d_b \times \sqrt{A_F}$ if $A_F > A_S$ $A_B = d_b \times \sqrt{A_S}$ if $A_S \geq A_F$			
Parameter	**Definition**	**Central Tendency**	**High End**
A_B	Area of buffer (m^2)		
d_b	Distance between source and field (side-length of buffer area) (m)	300	75
A_F	Area of off-site location of interest (m^2)	Ag. Field = 2,000,000 Residential plot or home garden = 5,100	
A_S	Area of source (m^2)	Waste management scenario-specific	

Table A-1.10. Scaling Factor

All Exposure Scenarios			
$$SF_{B,F} = \frac{A_F}{A_{B/Surr} + A_F}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
$SF_{B,F}$	Scaling factor		
A_F	Area of off-site location (m^2)	Ag. field = 2,000,000 Residential plot or home garden = 5,100	
$A_{B/Surr}$	Area of buffer and surrounding area (m^2)	Calculated (see Table A-1.5.)	
Description			
This term is used to determine what portion of the total amount of eroded buffer material available for deposition within the sub-basin, will be deposited onto just the off-site location of interest.			

Table A-1.11. Constituent Concentration Due to Erosion in Buffer and Surrounding Areas

All Exposure Scenarios			
$C_{B/Surr} = \frac{SL_{0,B/Surr} \times C_0 \times ER}{ks_{B/Surr} \times M_{B/Surr}} + \frac{Ds_{(1),B/Surr}}{ks_{B/Surr}}$			
Parameter	**Definition**	**Central Tendency**	**High End**
$C_{B/Surr}$	Constituent concentration in the buffer and surrounding area (mg/kg)		
$SL_{0,B/Surr}$	Soil load delivered to buffer and surrounding area (kg/yr)	Calculated (see Equation A-1.12.)	
C_0	Source constituent concentration (mg/kg)	Chemical-specific	
$ks_{B/Surr}$	Constituent loss constant for buffer and surrounding area (1/yr)	Calculated (see Equation A-1.15.)	
$M_{B/Surr}$	Mass of soil in mixing depth of buffer area (kg)	Calculated (see Equation A-1.23.)	
$Ds_{(1), B/Surr}$	Deposition term for off-site field (mg/kg.yr)	Calculated (see Table A-1.14.)	
ER	Constituent enrichment ratio (unitless)	Organics = 3 Metals = 1	
Description			
This equation is used to calculate the constituent concentration in the buffer and surrounding areas as a result of erosion from the source.			

Table A-1.12. Soil Load Delivered to Buffer and Surrounding Area for Material Originating from Source

All Exposure Scenarios			
$$SL_{0,B/Surr} = X_{e,S} \ x \ A_S \ x \ (1 - SD_{SB}) \ x \ SF_{0,B/Surr}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
$SL_{0,B/Surr}$	Soil load delivered to buffer and surrounding area (kg/yr)		
$X_{e,S}$	Unit soil loss from source (kg/m^2-yr)	Calculated (see Table A-1.3.)	
A_S	Area of source (m^2)	Source-specific	
SD_{SB}	Sediment delivery ratio for sub-basin (unitless)	Calculated (see Table A-1.4.)	
$SF_{O,B/Surr}$	Scaling factor	Calculated (see Table A-1.13.)	
Description			
This equation is used to calculate the load of eroded soil originating from the source that is deposited onto the buffer and surrounding areas.			

Table A-1.13. Scaling Factor

All Exposure Scenarios			
$$SF_{0,B/Surr} = \frac{A_{B/Surr}}{A_S + A_{B/Surr} + A_F}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
$SF_{0,B/surr}$	Scaling factor		
A_F	Area of off-site location (m^2)	Ag. field = 2,000,000 Residential plot or home garden = 5,100	
$A_{B/Surr}$	Area of buffer and surrounding area (m^2)	Calculated (see Table A-1.5.)	
A_S	Area of source (m^2)	Waste management scenario-specific	
Description			
This term is used to determine what portion of the total amount of eroded source material available for deposition within the sub-basin, will be deposited onto just the buffer and surrounding areas.			

Table A-1.14. Deposition Rate Factor to Buffer and Surrounding Areas

All Exposure Scenarios

$$Ds_{(1),B/Surr} = \frac{100 \; x \; Q}{Z_{B/Surr} \; x \; BD} \; x \; [F_v \; (0.31536 \; x \; Vdv_F \; x \; Cyv_F + Dywv_F) + (Dydp_F + Dywp_F) \; x \; (1 - F_v)$$

Parameter	Definition	Input Value
$Ds_{(1),B/Surr}$	Deposition term for buffer and surrounding areas (mg/kg-yr)	
100	Units conversion factor ([mg-m^2]/[kg-cm^2])	
Q	Source emissions (g/sec)	Waste mgt. scenario-specific
$Z_{B/surr}$	Soil mixing depth of buffer and surrounding areas - untilled (cm)	2.5
BD	Soil bulk density (g/cm^3)	1.5
F_v	Fraction of air concentration in vapor phase (dimensionless)	Chemical-specific (see Appendix B of Background Document)
0.31536	Units conversion factor (m-g-s/cm-µg-yr)	
Vdv_F	Dry deposition velocity for field (cm/s)	3
Cyv_F	Normalized vapor phase air concentration for field (µg-s/g-m^3)	Modeled (see Appendix B of Background Document)
$Dywv_F$	Normalized yearly wet deposition from vapor phase for field (s/m^2-yr)	Modeled (see Appendix B of Background Document)
$Dydp_F$	Normalized yearly dry deposition from particle phase for field (s/m^2-yr)	Modeled (see Appendix B of Background Document)
$Dywp_F$	Normalized yearly wet deposition from particle phase for field (s/m^2-yr)	Modeled (see Appendix B of Background Document)

Description

These equations calculate average air deposition occurring over the exposure duration as a result of wet and dry deposition of particles onto soil, deposition of wet vapors to soil and diffusion of dry vapors to soil. Contaminants are assumed to be incorporated only to a finite depth (the mixing depth, Z). The air deposition rates (per unit area) for the buffer and surrounding areas are assumed to be the same as the air deposition rates (per unit area) to the field.

Table A-1.15. Constituent Loss Constant

All Exposure Scenarios			
$$ks_{B/Surr} = ksl_{B/Surr} + kse_{B/Surr} + ksr_{B/Surr} + ksg_{B/surr} + ksv_{B/Surr}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
$ks_{B/Surr}$	Constituent loss constant due to all processes for the buffer and surrounding areas (1/yr)		
$ksl_{B/Surr}$	Constituent loss constant due to leaching (1/yr)	Calculated (see Table A-1.16.)	
$kse_{B/Surr}$	Constituent loss constant due to soil erosion (1/yr)	Calculated (see Table A-1.19.)	
$ksr_{B/Surr}$	Constituent loss constant due to surface runoff (1/yr)	Calculated (see Table A-1.21.)	
ksg_F	Constituent loss constant due to degradation (1/yr)	Chem. Specific (App. F of Background Document)	
$ksv_{B/Surr}$	Constituent loss constant due to volatilization (1/yr)	Calculated (see Table A-1.22.)	
Description			
This equation calculates the constitutent loss constant, which accounts for the loss of constituent from soil by several mechanisms.			

Table A-1.16. Constituent Loss Constant Due to Leaching

All Exposure Scenarios

$$ksl_{B/Surr} = \frac{P + I - R - E_v}{\theta \; x \; Z_{B/Surr} \; x \; [1.0 + (BD \; x \; Kd_s / \theta)]}$$

		Input Value	
Parameter	**Definition**	**Houston**	**LA**
$ksl_{B/Surr}$	Constituent loss constant for buffer and surrounding area due to leaching (1/yr)		
P	Average annual precipitation (cm/yr)	119.1	28.7
I	Average annual irrigation (cm/yr)	0	0
R	Average annual runoff (cm/yr)	13	1.3
E_v	Average annual evapotranspiration (cm/yr)	22.7	7.3
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
$Z_{B/Surr}$	Soil depth of buffer and surrounding area from which leaching removal occurs - untilled (cm)	2.5	
BD	Soil bulk density (g/cm^3)	1.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	

Description

This equation calculates the constituent loss constant due to leaching from soil.

Table A-1.17. Soil Volumetric Water Content

All Exposure Scenarios			
$\theta = \theta_s \left[\frac{q}{K_s} \right]^{\left(\frac{1}{2b+3} \right)}$			
Parameter	**Definition**	**Central Tendency**	**High End**
θ	Soil volumetric water content (mL/cm^3)		
θ_s	Soil saturated volumetric water content (mL/cm^3)	0.43	
q	Average annual recharge rate (cm/yr)	Calculated (see Table A-1.18.)	
K_s	Saturated hydraulic conductivity (cm/yr)	808	
b	Soil-specific exponent representing water retention (unitless)	5.4	

Source: SEAM.

Table A-1.18. Average Annual Recharge

All Exposure Scenarios			
$q = P + I - E_v - R_f$			
Parameter	**Definition**	**Central Tendency**	**High End**
q	Average annual recharge rate (cm/yr)		
P	Average annual precipitation (cm/yr)	119.1	28.7
I	Average annual irrigation (cm/yr)	0	
E_v	Average annual evapotranspiration (cm/yr)	22.7	7.3
R_f	Average annual runoff (cm/yr)	13	1.3

Source: SEAM.

Table A-1.19. Constituent Loss Constant Due to Erosion

All Exposure Scenarios

$$kse_{B/Surr} = \frac{0.1 \ x \ ER \ x \ X_{e,B/Surr} \ x \ [SD_{SB} + (1 - SD_{SB})(\frac{A_F}{A_{B/Surr} + A_F})]}{BD \ x \ Z_{B/Surr}} \ x \ \left(\frac{Kd_s \ x \ BD}{\theta + (Kd_s \ x \ BD)}\right)$$

Parameter	Definition	Central Tendency	High End
$kse_{B/Surr}$	Constituent loss constant for buffer and surrounding area due to soil erosion (1/yr)	Calculated	
$X_{e,B/Surr}$	Unit soil loss for buffer and surrounding area (kg/m^2/yr)	Calculated (see Table A-1.20.)	
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
$Z_{B/Surr}$	Soil mixing depth for buffer and surrounding area - untilled (cm)	2.5	
BD	Soil bulk density (g/cm^3)	1.5	
Kd_s	Soil-water partition coefficient (mL/g)	Chemical-specific (see Appendix F of Background Document)	
SD_{SB}	Sediment delivery ratio for the sub-basin (unitless)	Calculated (see Table A-1.4).	
ER	Constituent enrichment ratio (unitless)	Organics = 3 Metals - 1	
A_F	Area of off-site location (m^2)	Ag. Field = 2,000,000 Residential plot or home garden = 5,100	
$A_{B/Surr}$	Buffer and surrounding areas (m^2)	Calculated (See Table A-1.5.)	

Table A-1.20. Universal Soil Loss Equation (USLE) for Buffer and Surrounding Areas

All Exposure Scenarios

$$X_{e,B/Surr} = R_{B/Surr} \; x \; K_{B/Surr} \; x \; LS_{B/Surr} \; x \; C_{B/Surr} \; x \; P_{B/Surr} \; x \; \frac{907.18}{4047}$$

Parameter	Definition	Central Tendency	High End
$X_{e,B/Surr}$	Unit soil loss for buffer and surrounding area (kg/m^2 -yr)		
$R_{B/Surr}$	USLE rainfall factor (1/yr)	428	50
$K_{B/Surr}$	USLE erodibility factor (ton/acre)	0.37	
$LS_{B/Surr}$	USLE length-slope factor (unitless)	1.5	
$C_{B/Surr}$	USLE cover factor (unitless)	0.1	
$P_{B/Surr}$	USLE erosion control practice factor (unitless)	1.0	
907.18	Units conversion factor (kg/ton)		
4047	Units conversion factor (m^2/acre)		

Description

This equation is used to calculate the soil loss rate from the buffer and surrounding area using the Universal Soil Loss Equation; the result is used in the soil erosion load equation.

Table A-1.21. Constituent Loss Constant Due to Runoff

All Exposure Scenarios			
$$ksr_{B/Surr} = \frac{R}{\theta \; x \; Z_{B/Surr}} \; x \left(\frac{1}{1 + (Kd_s \; x \; BD/\theta)} \right)$$			
Parameter	**Definition**	**Central Tendency**	**High End**
$ksr_{B/Surr}$	Constituent loss constant for buffer and surrounding area due to runoff (1/yr)		
R	Average annual runoff (cm/yr)	13	1.3
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.))	
$Z_{B/Surr}$	Soil mixing depth of buffer and surrounding area - untilled (cm)	2.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
BD	Soil bulk density (g/cm^3)	1.5	
Description			
This equation calculates the constituent loss constant due to runoff from soil.			

Table A-1.22. Constituent Loss Constant Due to Volatilization

All Exposure Scenarios			
$$ksv_{B/Surr} = \left[\frac{3.1536x10^{7}\ x\ H}{Z_{B/Surr}\ x\ Kd_{s}\ x\ R\ x\ T\ x\ BD}\right] x \left[0.482\ x\ u^{0.78}\ x \left(\frac{\mu_a}{\rho_a\ x\ D_a}\right)^{-0.67} x \left(\sqrt{\frac{4\ x\ A_{B/Surr}}{\pi}}\right)^{-0.11}\right]$$			
Parameter	**Definition**	**Central Tendency**	**High End**
$ksv_{B/surr}$	Constituent loss constant for buffer and surrounding area due to volatilization (1/yr)		
$3.1536x10^{7}$	Conversion constant (s/yr)		
H	Henry's law constant (atm-m^3/mol)	Chemical-specific (see Appendix F of Background Document)	
$Z_{B/Surr}$	Soil mixing depth of buffer and surrounding area - untilled (cm)	2.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
R	Universal gas constant (atm-m^3/mol-K)	$8.205x10^{-5}$	
T	Ambient air temperature (K)	294	290
BD	Soil bulk density (g/cm^3)	1.5	
u	Average annual windspeed (m/s)	4.1	4.1
μ_a	Viscosity of air (g/cm-s)	$1.81x10^{-4}$	
ρ_a	Density of air (g/cm^3)	$1.2x10^{-3}$	
D_a	Diffusivity of constituent in air (cm^2/s)	Chemical-specific (see Appendix F of Background Document)	
$A_{B/Surr}$	Surface area of buffer and surrounding area (m^2)	Calculated (see Table A-1.5.)	
Description			
This equation calculates the constituent loss constant due to volatilization from soil.			

Source: IEM.

Table A-1.23. Mass of Soil in Mixing Depth of Buffer and Surrounding Areas

All Exposure Scenarios			
$M_{B/Surr} = Z_{B/Surr} \; x \; A_{B/Surr} \; x \; BD \; x \; 10$			
Parameter	**Definition**	**Central Tendency**	**High End**
$M_{B/Surr}$	Mass of soil in mixing depth of buffer and surrounding area (kg)		
$Z_{B/Surr}$	Soil mixing depth for buffer and surrounding area - untilled (cm)	2.5	
$A_{B/Surr}$	Area of buffer and surrounding areas (m^2)	Calculated (see Table A-1.5.)	
BD	Soil bulk density (g/cm^3)	1.5	
10	Units conversion factor		
Description			
This equation is used to calculate the total mass of soil in the buffer and surrounding areas that will be mixing with the mass of eroded material.			

Table A-1.24. Deposition Rate Factor to Residential Plot from Source

Adult Resident Exposure Scenario

$$Ds_{(1),R} = \frac{100 \; x \; Q}{Z_F \; x \; BD} \; x \; [F_v \; (0.31536 \; x \; Vdv_F \; x \; Cyv_F + Dywv_F) + (Dydp_F + Dywp_F) \; x \; (1 - F_v)]$$

Parameter	Definition	Input Value
$Ds_{(1),R}$	Deposition term for residential plot - Adult Resident (mg/kg-yr)	
100	Units conversion factor ([mg-m^2]/[kg-cm^2])	
Q	Source emissions (g/m^2-s)	Waste mgt. scenario-specific
Z_F	Soil mixing depth of residential plot - untilled (cm)	2.5
BD	Soil bulk density (g/cm^3)	1.5
F_v	Fraction of air concentration in vapor phase (dimensionless)	Chemical-specific (see Appendix B of Background Document)
0.31536	Units conversion factor (m-g-s/cm-µg-yr)	
Vdv_F	Dry deposition velocity for field (cm/s)	3
Cyv_F	Normalized vapor phase air concentration for field (μmg-s/g-m)	Modeled (see Appendix B of Background Document)
$Dywv_F$	Normalized yearly wet deposition from vapor phase for field (s/yr)	Modeled (see Appendix B of Background Document)
$Dydp_F$	Normalized yearly dry deposition from particle phase for field (s/yr)	Modeled (see Appendix B of Background Document)
$Dywp_F$	Normalized yearly wet deposition from particle phase for field (s/yr)	Modeled (see Appendix B of Background Document)

Description

These equations calculate average air deposition occurring over the exposure duration as a result of wet and dry deposition of particles onto soil, deposition of wet vapors to soil, and diffusion of dry vapors to soil. Contaminants are assumed to be incorporated only to a finite depth (the mixing depth, Z).

Table A-1.25. Constituent Loss Constant

Adult Resident Exposure Scenario			
$ks_R = ksl_R + kse_R + ksr_R + ksg_R + ksv_R$			
Parameter	**Definition**	**Central Tendency**	**High End**
ks_R	Constituent loss constant due to all processes from resident plot - Adult Resident (1/yr)		
ksl_R	Constituent loss due to leaching (1/yr)	Calculated (see Table A-1.26.)	
kse_R	Constituent loss due to soil erosion (1/yr)	Calculated (see Table A-1.27.)	
ksr_R	Constituent loss due to surface runoff (1/yr)	Calculated (see Table A-1.30.)	
ksg_R	Constituent loss due to degradation (1/yr)	Chem. Specific (see Appendix F of Background Document)	
ksv_R	Constituent loss due to volatilization (1/yr)	Calculated (see Table A-.31..)	
Description			
This equation calculates the constituent loss constant, which accounts for the loss of constituent from soil by several mechanisms.			

Table A-1.26. Constituent Loss Constant Due to Leaching

Adult Resident Exposure Scenario			
$$ksl_R = \frac{P + I - R - E_v}{\theta \ x \ Z_R \ x \ [1.0 + (BD \ x \ Kd_s/\theta)]}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
ksl_R	Constituent loss residential plot due to leaching - Adult Resident (1/yr)		
P	Average annual precipitation (cm/yr)	119.1	28.7
I	Average annual irrigation (cm/yr)	0	0
R	Average annual runoff (cm/yr)	13	1.3
E_v	Average annual evapotranspiration (cm/yr)	22.7	7.3
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
Z_R	Soil depth for residential plot which leaching removal occurs - untilled (cm)	2.5	
BD	Soil bulk density (g/cm^3)	1.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
Description			
This equation calculates the constituent loss constant to leaching from soil.			

Table A-1.27. Constituent Loss Constant Due to Erosion

Adult Resident Exposure Scenario

$$kse_R = \frac{0.1 \ x \ ER \ x \ X_{e,R} \ x \ [SD_{SB} + (1 - SD_{SB})(\frac{A_{BF}}{A_F + A_{BF}})]}{BD \ x \ Z_R} \ x \ \left(\frac{Kd_s \ x \ BD}{\theta + (Kd_s \ x \ BD)} \right)$$

Parameter	Definition	Central Tendency	High End
kse_R	Constituent loss constant due to erosion for residential plot - Adult Resident (1/yr)		
$X_{e,R}$	Unit soil loss from the residential plot (kg/m^2/yr)	Calculated (see Table A-1.28.)	
SD_{SB}	Sediment delivery ratio for sub-basin (unitless)	Calculated (see Table A-1.4.)	
ER	Contaminant enrichment ratio (unitless)	Organics = 3 Metals = 1	
BD	Soil bulk density (g/cm^3)	1.5	
Z_F	Soil mixing depth of residential plot - untilled (cm)	2.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
A_F	Area of residential plot (m2)	Residential plot = 5,100	
A_{BF}	Buffer area between residential plot and waterbody (m^2)	Calculated (see Table A-1.29..)	

Description

This equation calculates the constituent loss constant due to runoff from soil.

Table A-1.28. Universal Soil Loss Equation (USLE) for Residential Plot

Adult Resident Exposure Scenario

$$X_{e,R} = R_R \times K_R \times LS_R \times C_R \times P_R \times \frac{907.18}{4047}$$

Parameter	Definition	Central Tendency	High End
$X_{e,R}$	Unit soil loss from the residential plot (kg/m^2 -yr)		
R_R	USLE rainfall factor (1/yr)	428	50
K_R	USLE erodibility factor (ton/acre)	0.37	
LS_R	USLE length-slope factor (unitless)	1.5	
C_R	USLE cover factor (unitless)	0.1	
P_R	USLE erosion control practice factor (unitless)	1.0	
907.18	Units conversion factor (kg/ton)		
4047	Units conversion factor (m^2/acre)		

Description

This equation is used to calculate the soil loss rate from the residential plot using the Universal Soil Loss Equation.

Table A-1.29. Area of Buffer Between Field and Waterbody

All Exposure Scenarios

$$A_{BF} = 0 \qquad if \quad \sqrt{A_S} \leq d_b + \sqrt{A_F}$$

$$A_{BF} = \sqrt{A_F} \; x \; (\sqrt{A_S} - d_b - \sqrt{A_F}) \qquad if \quad \sqrt{A_S} > d_b + \sqrt{A_F}$$

Parameter	Definition	Central Tendency	High End
A_{BF}	Area of buffer between field and waterbody (m^2)		
A_F	Area of field (m^2)	Ag. Field = 2,000,000 Residential plot or home garden = 5,100	
A_S	Area of source (m^2)	Waste management scenario-specific	
d_b	Distance between source and field (side-length of buffer area) (m)	300	75

Table A-1.30. Constituent Loss Constant Due to Runoff

Adult Resident Exposure Scenario			
$$ksr_R = \frac{R}{\theta \times Z_R} \times \left(\frac{1}{1 + (Kd_s \times BD/\theta)}\right)$$			
Parameter	**Definition**	**Central Tendency**	**High End**
ksr_R	Constituent loss constant due to runoff for residential plot - Adult Resident (1/yr)		
R	Average annual runoff (cm/yr)	13	1.3
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
Z_R	Soil mixing depth of residential plot - untilled (cm)	2.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
BD	Soil bulk density (g/cm^3)	1.5	
Description			
This equation calculates the constituent loss constant due to runoff from soil.			

Table A-1.31. Constituent Loss Constant Due to Volatilization

Adult Resident Exposure Scenario

$$ksv_R = \left[\frac{3.1536x10^{7}\ x\ H}{Z_R\ x\ Kd_s\ x\ R\ x\ T\ x\ BD}\right] x \left[0.482\ x\ u^{0.78}\ x \left(\frac{\mu_a}{\rho_a\ x\ D_a}\right)^{-0.67} x \left(\sqrt{\frac{4\ x\ A}{\pi}}\right)^{-0.11}\right]$$

Parameter	Definition	Central Tendency	High End
ksv_R	Constituent loss constant due to volatilization from residential plot - Adult Resident (1/yr)		
$3.1536x10^{7}$	Conversion constant (s/yr)		
H	Henry's law constant (atm-m^3/mol)	Chemical-specific (see Appendix F of Background Document)	
Z_R	Soil mixing depth of residential plot - untilled (cm)	2.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
R	Universal gas constant (atm-m^3/mol-K)	$8.205x10^{-5}$	
T	Ambient air temperature (K)	294	290
BD	Soil bulk density (g/cm^3)	1.5	
u	Average annual windspeed (m/s)	4.1	4.1
μ_a	Viscosity of air (g/cm-s)	$1.81x10^{-4}$	
ρ_a	Density of air (g/cm^3)	$1.2x10^{-3}$	
D_a	Diffusivity of constituent in air (cm^2/s)	Chemical-specific (see Appendix F of Background Document)	
A_F	Area of residential plot (m^2)	5,100	

Description

This equation calculates the constituent loss constant due to volatilization from soil.

Table A-1.32. Mass of Soil in Mixing Depth of Residential Plot

Adult Resident Exposure Scenario			
$$M_R = Z_R \; x \; A_F \; x \; BD \; x \; 10$$			
Parameter	**Definition**	**Central Tendency**	**High End**
M_R	Mass of soil in mixing depth of residential plot - Adult Resident (kg)		
Z_R	Soil mixing depth for residential plot - untilled (cm)	2.5	
A_F	Area of residential plot (m^2)	5,100	
BD	Soil bulk density (g/cm^3)	1.5	
10	Units conversion factor		
Description			
This equation is used to calculate the total mass of soil in the residential plot that will be mixing with the mass of eroded material.			

Table A-2.1. Concentration In Home Garden Due to Erosion

Home Gardener Exposure Scenario

$$C_{HG} = \frac{SL_{0,F} \ x \ C_0 \ x \ ER}{ks_{HG} \ x \ M_{HG}} + \frac{SL_{B,F} \ x \ C_{B/Surr} \ x \ ER}{ks_{HG} \ x \ M_{HG}} + \frac{Ds_{(1),HG}}{ks_{HG}}$$

Parameter	Definition	Central Tendency	High End
C_{HG}	Constituent concentration at home garden (mg/kg)		
$SL_{0,F}$	Soil load delivered to off-site location for material originating in source area (kg/yr)	Calculated (see Equation A-1.2.)	
$SL_{B,F}$	Soil load delivered to off-site location for material originating in buffer area (kg/yr)	Calculated (see Equation A-1.7.)	
$C_{B/Surr}$	Constituent concentration in buffer and surrounding areas (mg/kg)	Calculated (see Equation A-1.11)	
$Ds_{(1),HG}$	Deposition term for the home garden (mg/kg.yr)	Calculated (see Equation A-2.9.)	
C_0	Source constituent concentration (mg/kg)	Chemical-specific	
ks_{HG}	Constituent loss constant from the home garden (1/yr)	Calculated (see Equation A-2.2.)	
ER	Constituent enrichment ratio (unitless)	organics = 3 metals = 1	
M_{HG}	Mass of soil in mixing depth of home garden (kg)	Calculated (see Equation A-2.8.)	

Description

This equation is used to calculate the mass of constituent deposited onto either the home garden as a result of erosion from the source.

Table A-2.2. Constituent Loss Constant

Home Gardener Exposure Scenario			
$ks_{HG} = ksl_{HG} + kse_{HG} + ksr_{HG} + ksg_{HG} + ksv_{HG}$			
Parameter	**Definition**	**Central Tendency**	**High End**
ks_{HG}	Constituent soil loss constant due to all processes from home garden (1/yr)		
ksl_{HG}	Constituent loss constant due to leaching (1/yr)	Calculated (see Table A-2.3.)	
kse_{HG}	Constituent loss constant due to soil erosion (1/yr)	Calculated (see Table A-2.4)	
ksr_{HG}	Constituent loss constant due to surface runoff (1/yr)	Calculated (see Table A-2.6.)	
ksg_{HG}	Constituent loss constant due to degradation (1/yr)	Chemical specific (see Appendix F of Background Document)	
ksv_{HG}	Constituent loss constant due to volatilization (1/yr)	Calculated (see Table A-2.7.)	
Description			
This equation calculates the constituent loss constant, which accounts for the loss of constituent from soil by several mechanisms.			

Table A-2.3. Constituent Loss Constant Due to Leaching

Home Gardener Exposure Scenario			
$$ksl_{HG} = \frac{P + I - R - E_v}{\theta \; x \; Z_{HG} \; x \; [1.0 + (BD \; x \; Kd_s / \theta)]}$$			
		Input Value	
Parameter	**Definition**	**Houston**	**LA**
ksl_{HG}	Constituent loss constant due to leaching for home gardener (1/yr)		
P	Average annual precipitation (cm/yr)	119.1	28.7
I	Average annual irrigation (cm/yr)	0	0
R	Average annual runoff (cm/yr)	13	1.3
E_v	Average annual evapotranspiration (cm/yr)	22.7	7.3
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
Z_{HG}	Soil depth of home garden from which leaching removal occurs – tilled (cm)	20	
BD	Soil bulk density (g/cm^3)	1.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
Description			
This equation calculates the constituent loss constant due to leaching from soil.			

Table A-2.4. Constituent Loss Constant Due to Erosion

Home Gardener Exposure Scenario

$$kse_{HG} = \frac{0.1 \ x \ ER \ x \ X_{e,HG} \ x \ [SD_{SB} + (1 - SD_{SB})(\frac{A_{BF}}{A_F + A_{BF}})]}{BD \ x \ Z_{HG}} \ x \ \left(\frac{Kd_s \ x \ BD}{\theta + (Kd_s \ x \ BD)} \right)$$

Parameter	Definition	Central Tendency	High End
kse_{HG}	Constituent loss constant due to erosion for home gardener (1/yr)		
$X_{e,HG}$	Unit soil loss from the home garden ($kg/m^2/yr$)	Calculated (see Table A-2.5.)	
SD_{SB}	Sediment delivery ratio for sub-basin (unitless)	Calculated (see Table A-1.4.)	
ER	Constituent enrichment ratio (unitless)	Organics = 3 Metals = 1	
BD	Soil bulk density (g/cm^3)	1.5	
Z_{HG}	Soil mixing depth of home garden – tilled (cm)	20	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
A_F	Area of home garden	5,100	
A_{BF}	Buffer area between home garden and waterbody (m^2)	Calculated (see Table A-1.29.)	

Description

This equation calculates the constituent loss constant due to runoff from soil.

Table A-2.5. Universal Soil Loss Equation (USLE) for Home Garden

Home Gardener Exposure Scenario

$$X_{e,HG} = RF_{HG} \times K_{HG} \times LS_{HG} \times C_{HG} \times P_{HG} \times \frac{907.18}{4047}$$

Parameter	**Definition**	**Central Tendency**	**High End**
$X_{e,HG}$	Unit soil loss from home garden ($kg/m^2/yr$)		
RF_{HG}	USLE rainfall factor (1/yr)	428	50
K_{HG}	USLE erodibility factor (ton/acre)	0.36	
LS_{HG}	USLE length-slope factor (unitless)	1.5	
C_{HG}	USLE cover management factor (unitless)	0.1	
P_{HG}	USLE supporting practice factor (unitless)	1	
907.18	Conversion factor (kg/ton)		
4047	Conversion factor (m^2/acre)		

Description

This equation is used to calculate the soil loss rate from the home garden using the Universal Soil Loss Equation.

Table A-2.6. Constituent Loss Constant Due to Runoff

Home Gardener Exposure Scenario			
$$ksr_{HG} = \frac{R}{\theta \; x \; Z_{HG}} \; x \left(\frac{1}{1 + (Kd_s \; x \; BD/\theta)} \right)$$			
Parameter	**Definition**	**Central Tendency**	**High End**
ksr_F	Constituent loss constant due to runoff for home gardener (1/yr)		
R	Average annual runoff (cm/yr)	13	1.3
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
Z_{HG}	Soil mixing depth of home garden – tilled (cm)	20	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
BD	Soil bulk density (g/cm^3)	1.5	
Description			
This equation calculates the constituent loss constant due to runoff from soil.			

Table A-2.7. Constituent Loss Constant Due to Volatilization

Home Gardener Exposure Scenario

$$ksv_{HG} = \left[\frac{3.1536x10^{7} \; x \; H}{Z_{HG} \; x \; Kd_{s} \; x \; R \; x \; T \; x \; BD}\right] x \left[0.482 \; x \; u^{0.78} \; x \left(\frac{\mu_a}{\rho_a \; x \; D_a}\right)^{-0.67} x \left(\sqrt{\frac{4 \; x \; A_F}{\pi}}\right)^{-0.11}\right]$$

Parameter	Definition	Central Tendency	High End
ksv_{HG}	Constituent loss constant due to volatilization for home gardener (1/yr)		
$3.1536x10^{7}$	Conversion constant (s/yr)		
H	Henry's law constant (atm-m^3/mol)	Chemical-specific (see Appendix F of Background Document)	
Z_{HG}	Soil mixing depth of home garden – tilled (cm)	20	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
R	Universal gas constant (atm-m^3/mol-K)	$8.205x10^{-5}$	
T	Ambient air temperature (K)	294	290
BD	Soil bulk density (g/cm^3)	1.5	
u	Average annual windspeed (m/s)	4.1	4.1
μ_a	Viscosity of air (g/cm-s)	$1.81x10^{-4}$	
ρ_a	Density of air (g/cm^3)	$1.2x10^{-3}$	
D_a	Diffusivity of constituent in air (cm^2/s)	Chemical-specific (see Appendix F of Background Document)	
A_F	Area of home garden (m^2)	5,100	

Description

This equation calculates the constituent loss constant due to volatilization from soil.

Table A-2.8. Mass of Soil in Mixing Depth of Home Garden

Home Gardener Exposure Scenario			
$M_{HG} = Z_{HG} \; x \; A_F \; x \; BD \; x \; 10$			
Parameter	**Definition**	**Central Tendency**	**High End**
M_{HG}	Mass of soil in mixing depth of home garden (kg)		
Z_{HG}	Soil mixing depth for home garden – tilled (cm)	20	
A_F	Area of home garden (m^2)	5,100	
BD	Soil bulk density (g/cm^3)	1.5	
10	Units conversion factor		
Description			
This equation is used to calculate the total mass of soil in the home garden that will be mixing with the mass of eroded material.			

Table A-2.9. Deposition Rate Factor to Home Garden from Source

Home Gardener Exposure Scenario

$$Ds_{(1),HG} = \frac{100 \; x \; Q}{Z_{HG} \; x \; BD} \; x \; [F_v \; (0.31536 \; x \; Vdv_{HG} \; x \; Cyv_{HG} + Dywv_{HG}) + (Dydp_{HG} + Dywp_{HG}) \; x \; (1 - F_v)]$$

Parameter	Definition	Input Value
$Ds_{(1),HG}$	Deposition term for home garden (mg/kg-yr)	
100	Units conversion factor ([mg-m^2]/[kg-cm^2])	
Q	Source emissions (g/sec)	Waste mgt. scenario-specific
Z_{HG}	Soil mixing depth of home garden – tilled (cm)	20
BD	Soil bulk density (g/cm^3)	1.5
F_v	Fraction of air concentration in vapor phase (dimensionless)	Chemical-specific (see Appendix B of Background Document)
0.31536	Units conversion factor (m-g-s/cm-µg-yr)	
Vdv_{HG}	Dry deposition velocity for home garden (cm/s)	3
Cyv_{HG}	Normalized vapor phase air concentration for home garden (µg-s/g-m^3)	Modeled (see Appendix B of Background Document)
$Dywv_{HG}$	Normalized yearly wet deposition from vapor phase for home garden (s/m^2-yr)	Modeled (see Appendix B of Background Document)
$Dydp_{HG}$	Normalized yearly dry deposition from particle phase for home garden (s/m^2-yr)	Modeled (see Appendix B of Background Document)
$Dywp_{HG}$	Normalized yearly wet deposition from particle phase for home garden (s/m^2-yr)	Modeled (see Appendix B of Background Document)

Description

These equations calculate average air deposition occurring over the exposure duration as a result of wet and dry deposition of particles onto soil, deposition of wet vapors to soil, and diffusion of dry vapors to soil. Constituents are assumed to be incorporated only to a finite depth (the mixing depth, Z).

Table A-2.10. Aboveground Produce Concentration Due to Direct Deposition

Home Gardener Scenario

$$Pd_{HG} = \frac{1000 \; x \; Q \; x \; (1 - F_v) \; x \; [Dydp_{HG} + (Fw \; x \; Dywp_{HG})] \; x \; Rp \; x \; [(1.0 - \exp(-kp \; x \; Tp)]}{Yp \; x \; kp}$$

Parameter	Definition	Central Tendency	High End
Pd_{HG}	Concentration in plant due to direct deposition (mg/kg) - Home Gardener		
1000	Units conversion factor (mg/g)		
Q	Emissions (g)	Waste mgt. scenario-specific	
F_v	Fraction of air concentration in vapor phase (dimensionless)	Chemical-specific (see Appendix F of Background Document)	
$Dydp_{HG}$	Normalized yearly dry deposition from particle phase (s/m^2-yr)	Modeled (see Appendix B of Background Document)	
Fw	Fraction of wet deposition that adheres to plant (dimensionless)	Chemical-specific (see Appendix F of Background Document)	
$Dywp_{HG}$	Yearly particle phase wet deposition rate (g/m^2/yr)	Modeled (see Appendix B of Background Document)	
Rp	Interception fraction of edible portion of plant (dimensionless) - aboveground vegetable - forage - root vegetable	 0.04 0.5	
kp	Plant surface loss coefficient (1/yr)	18	
Tp	Length of plant exposure to deposition of edible portion of plant, per harvest (yrs) - grain, root vegetable and aboveground vegetable - forage	0.16 0.12	
Yp	Yield or standing crop biomass of the edible portion of the plant (kg DW/m^2) - grain - root vegetable - aboveground vegetable - forage	 0.3 0.09 1.74 0.24	 0.14 0.09

Description

This equation calculates the constituent concentration in aboveground vegetation due to wet and dry deposition of constituent on the plant surface.

Table A-2.11. Aboveground Produce Concentration Due to Air-to-Plant Transfer

Home Gardener Scenario		
$$Pv_{HG} = Q \ x \ F_v \ x \ \frac{Cyv_{HG} \ x \ Bv \ x \ VG_{ag}}{\rho_a}$$		
Parameter	**Definition**	**Default Value**
Pv_{HG}	Concentration of constituent in the plant due to air-to-plant transfer (mg/kg) - Home Gardener	
Q	Emissions (g)	Waste mgt. scenario-specific
F_v	Fraction of air concentration in vapor phase (dimensionless)	Chemical-specific (see Appendix F of Background Document)
Cyv_{HG}	Normalized vapor phase air concentration (µg-sec/g-m^3)	Modeled (see Appendix B of Background Document)
Bv	Air-to-plant biotransfer factor ([mg constituent/kg plant tissue DW]/[µg constituent/g air])	Chemical-specific (see Appendix F of Background Document)
VG_{ag}	Empirical correction factor for above-ground produce (dimensionless)	0.01
ρ_a	Density of air (g/cm^3)	$1.2 \ x \ 10^{-3}$
Description		
This equation calculates the constituent concentration in aboveground vegetation due to direct uptake of vapor phase chemicals into the plant leaves.		

Table A-2.12. Aboveground Produce Concentration Due to Root Uptake

Home Gardener Scenario			
$Pr_{HG} = C_{HG} \times Br$			
Parameter	**Definition**	**Central Tendency**	**High End**
Pr_{HG}	Concentration of constituent in the plant due to direct uptake from soil (mg/kg) - Home Gardener		
C_{HG}	Average soil concentration of constituent over exposure duration (mg/kg)	Calculated (see Table A-2.1.)	
Br	Plant-soil bioconcentration factor for aboveground produce [µg/g DW]/[µg/g soil]	Chemical-specific (see Appendix F see Background Document)	
Description			
This equation calculates the constituent concentration in aboveground vegetation due to direct uptake of chemicals from soil.			

Table A-2.13. Root Vegetable Concentration Due to Root Uptake

Home Gardener Scenario			
$$Pr_{bg,HG} = \frac{C_{HG} \times RCF}{Kd_s}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
$Pr_{bg,\ HG}$	Concentration of constituent in belowground plant parts due to root uptake (mg/kg) - Home Gardener		
C_{HG}	Soil concentration of constituent (mg/kg)	Calculated (see Table A-2.1.)	
RCF	Ratio of concentration in roots to concentration in soil pore water ([mg constituent/kg plant tissue FW] / [μg constituent/mL pore water])	Chemical-specific (see Appendix F of Background Document)	
Kd_s	Soil-water partition coefficient (mL/g)	Chemical-specific (see Appendix F of Background Document)	
Description			
This equation calculates the constituent concentration in root vegetables due to uptake from the soil water.			

Table A-3.1. Constituent Concentration In Agricultural Field Due to Erosion

Subsistence Farmer Exposure Scenario

$$C_{SF} = \frac{SL_{0,F} \ x \ C_0 \ x \ ER}{ks_{SF} \ x \ M_{SF}} + \frac{SL_{B,F} \ x \ C_{B/Surr} \ x \ ER}{ks_{SF} \ x \ M_{SF}} + \frac{Ds_{(1),SF}}{ks_{SF}}$$

Parameter	Definition	Central Tendency	High End
C_{SF}	Constituent concentration in agricultural field (mg/kg)		
$SL_{0,F}$	Soil load delivered to off-site location for material originating in source area (kg/yr)	Calculated (see Equation A-1.2.)	
$SL_{B,F}$	Soil load delivered to off-site location for material originating in buffer area (kg/yr)	Calculated (see Equation A-1.7.)	
$C_{B/Surr}$	Constituent concentration in buffer and surrounding areas (mg/kg)	Calculated (see Equation A-1.11.)	
$Ds_{(1),SF}$	Deposition term for the agricultural field (mg/kg.yr)	Calculated (see Equation A-3.9.)	
C_0	Source constituent concentration (mg/kg)	Chemical-specific	
ks_{SF}	Constituent loss constant from the agricultural field (1/yr)	Calculated (see Equation A-3.2.)	
M_{SF}	Mass of soil in mixing depth of agricultural field (kg)	Calculated (see Equation A-3.8.)	
ER	Constituent enrichment ratio (unitless)	organics = 3 metals = 1	

Description

This equation is used to calculate the mass of constituent deposited onto the agricultural field as a result of erosion from the source.

Table A-3.2. Soil Loss Constant

Subsistence Farmer Exposure Scenario			
$$ks_{SF} = ksl_{SF} + kse_{SF} + ksr_{SF} + ksg_{SF} + ksv_{SF}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
ks_{SF}	Constituent soil loss constant due to all processes from agricultural field (1/yr)		
ksl_{SF}	Constituent loss constant due to leaching (1/yr)	Calculated (see Table A-3.3.)	
kse_{SF}	Constituent loss constant due to soil erosion (1/yr)	Calculated (see Table A-3.4)	
ksr_{SF}	Constituent loss constant due to surface runoff (1/yr)	Calculated (see Table A-3.6.)	
ksg_{SF}	Constituent loss constant due to degradation (1/yr)	Chemical-specific (see Appendix F of Background Document)	
ksv_{SF}	Constituent loss constant due to volatilization (1/yr)	Calculated (see Table A-3.7.)	
Description			
This equation calculates the constituent loss constant, which accounts for the loss of constituent from soil by several mechanisms.			

Table A-3.3. Loss Constant due to Leaching

Subsistence Farmer Exposure Scenario			
$$ksl_{SF} = \frac{P + I - R - E_v}{\theta \ x \ Z_{SF} \ x \ [1.0 + (BD \ x \ Kd_s / \theta)]}$$			
		Input Value	
Parameter	**Definition**	**Houston**	**LA**
ksl_{SF}	Constituent loss constant due to leaching for agricultural field (1/yr)		
P	Average annual precipitation (cm/yr)	119.1	28.7
I	Average annual irrigation (cm/yr)	0	0
R	Average annual runoff (cm/yr)	13	1.3
E_v	Average annual evapotranspiration (cm/yr)	22.7	7.3
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
Z_{SF}	Soil depth of agricultural field from which leaching removal occurs – tilled (cm)	20	
BD	Soil bulk density (g/cm^3)	1.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
Description			
This equation calculates the constituent loss constant due to leaching from soil.			

Table A-3.4. Constituent Loss Constant Due to Erosion

Subsistence Farmer Exposure Scenario

$$kse_{SF} = \frac{0.1 \; x \; ER \; x \; X_{e,SF} \; x \; [SD_{SB} + (1 - SD_{SB})(\frac{A_{BF}}{A_F + A_{BF}})]}{BD \; x \; Z_{SF}} \; x \; \left(\frac{Kd_s \; x \; BD}{\theta + (Kd_s \; x \; BD)} \right)$$

Parameter	Definition	Central Tendency	High End
kse_{SF}	Constituent loss constant due to erosion for agricultural field (1/yr)		
$X_{e,SF}$	Unit soil loss from the agricultural field ($kg/m^2/yr$)	Calculated (see Table A-3.5.)	
SD_{SB}	Sediment delivery ratio for sub-basin (unitless)	Calculated (see Table A-1.4.)	
ER	Constituent enrichment ratio (unitless)	Organics = 3 Metals = 1	
BD	Soil bulk density (g/cm^3)	1.5	
Z_{SF}	Soil mixing depth of agricultural field– tilled (cm)	20	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
A_F	Area of agricultural field (m^2)	2,000,000	
A_{BF}	Buffer area between agricultural field and waterbody (m^2)	Calculated (see Table A-1.29.)	

Description

This equation calculates the constituent loss constant due to runoff from soil.

Table A-3.5. Universal Soil Loss Equation (USLE) for Agricultural Field

Subsistence Farmer Exposure Scenario

$$X_{e,SF} = RF_{SF} \times K_{SF} \times LS_{SF} \times C_{SF} \times P_{SF} \times \frac{907.18}{4047}$$

Parameter	Definition	Central Tendency	High End
$X_{e,SF}$	Unit soil loss from the agricultural field ($kg/m^2/yr$)		
RF_{SF}	USLE rainfall factor (1/yr)	428	50
K_{SF}	USLE erodibility factor (ton/acre)	0.37	
LS_{SF}	USLE length-slope factor (unitless)	1.5	
C_{SF}	USLE cover management factor (unitless)	0.1	
P_{SF}	USLE supporting practice factor (unitless)	1	
907.18	Conversion factor (kg/ton)		
4047	Conversion factor (m^2/acre)		

Description

This equation is used to calculate the soil loss rate from the agricultural field using the Universal Soil Loss Equation.

Table A-3.6. Constituent Loss Constant Due to Runoff

Subsistence Farmer Exposure Scenario			
$$ksr_{SF} = \frac{R}{\theta \; x \; Z_{SF}} \; x \left(\frac{1}{1 + (Kd_s \; x \; BD/\theta)} \right)$$			
Parameter	**Definition**	**Central Tendency**	**High End**
ksr_{SF}	Constituent loss constant due to runoff from agricultural field (1/yr)		
R	Average annual runoff (cm/yr)	13	1.3
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
Z_{SF}	Soil mixing depth of agricultural field– tilled (cm)	20	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
BD	Soil bulk density (g/cm^3)	1.5	
Description			
This equation calculates the constituent loss constant due to runoff from soil.			

Table A-3.7. Constituent Loss Constant Due to Volatilization

Subsistence Farmer Exposure Scenario

$$ksv_{SF} = \left[\frac{3.1536x10^{7}\ x\ H}{Z_{SF}\ x\ Kd_s\ x\ R\ x\ T\ x\ BD}\right] x \left[0.482\ x\ u^{0.78}\ x \left(\frac{\mu_a}{\rho_a\ x\ D_a}\right)^{-0.67} x \left(\sqrt{\frac{4\ x\ A_F}{\pi}}\right)^{-0.11}\right]$$

Parameter	Definition	Central Tendency	High End
ksv_{SF}	Constituent loss constant due to volatilization for agricultural field (1/yr)		
$3.1536x10^{7}$	Conversion constant (s/yr)		
H	Henry's law constant (atm-m^3/mol)	Chemical-specific (see Appendix F of Background Document)	
Z_{SF}	Soil mixing depth of agricultural field (cm)	20	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
R	Universal gas constant (atm-m^3/mol-K)	$8.205x10^{-5}$	
T	Ambient air temperature (K)	294	290
BD	Soil bulk density (g/cm^3)	1.5	
u	Average annual windspeed (m/s)	4.1	4.1
μ_a	Viscosity of air (g/cm-s)	$1.81x10^{-4}$	
ρ_a	Density of air (g/cm^3)	$1.2x10^{-3}$	
D_a	Diffusivity of constituent in air (cm^2/s)	Chemical-specific (see Appendix F of Background Document)	
A_F	Area of agricultural field (m^2)	2,000,000	

Description

This equation calculates the constituent loss constant due to volatilization from soil.

Table A-3.8. Mass of Soil in Mixing Depth of Agricultural Field

Subsistence Farmer Exposure Scenario			
$M_{SF} = Z_{SF} \ x \ A_F \ x \ BD \ x \ 10$			
Parameter	**Definition**	**Central Tendency**	**High End**
M_{SF}	Mass of soil in mixing depth of agricultural field (kg)		
Z_{SF}	Soil mixing depth for agricultural field – tilled (cm)	20	
A_F	Area of agricultural field (m^2)	2,000,000	
BD	Soil bulk density (g/cm^3)	1.5	
10	Units conversion factor		
Description			
This equation is used to calculate the total mass of soil in the agricultural field that will be mixing with the mass of eroded material.			

Table A-3.9. Deposition Rate Factor to Agricultural Field from Source

Subsistence Farmer Exposure Scenario

$$Ds_{(1),SF} = \frac{100\ x\ Q}{Z_{SF}\ x\ BD}\ x\ [F_v\ (0.31536\ x\ Vdv_{SF}\ x\ Cyv_{SF} + Dywv_{SF}) + (Dydp_{SF} + Dywp_{SF})\ x\ (1 - F_v)]$$

Parameter	Definition	Input Value
$Ds_{(1),SF}$	Deposition term for agricultural field (mg/kg-yr)	
100	Units conversion factor ([mg-m^2]/[kg-cm^2])	
Q	Source emissions (g/sec)	Waste mgt. scenario-specific
Z_{SF}	Soil mixing depth of agricultural field (cm)	20
BD	Soil bulk density (g/cm^3)	1.5
F_v	Fraction of air concentration in vapor phase (dimensionless)	Chemical-specific (see Appendix B of Background Document)
0.31536	Units conversion factor (m-g-s/cm-µg-yr)	
Vdv_{SF}	Dry deposition velocity for agricultural field (cm/s)	3
Cyv_{SF}	Normalized vapor phase air concentration for agricultural field (µg-s/g-m^3)	Modeled (see Appendix B of Background Document)
$Dywv_{SF}$	Normalized yearly wet deposition from vapor phase for agricultural field (s/m^2-yr)	Modeled (see Appendix B of Background Document)
$Dydp_{SF}$	Normalized yearly dry deposition from particle phase for agricultural field (s/m^2-yr)	Modeled (see Appendix B of Background Document)
$Dywp_{SF}$	Normalized yearly wet deposition from particle phase for agricultural field (s/m^2-yr)	Modeled (see Appendix B of Background Document)

Description

These equations calculate average air deposition occurring over the exposure duration as a result of wet and dry deposition of particles onto soil, deposition of wet vapors to soil, and diffusion of dry vapors to soil. Constituents are assumed to be incorporated only to a finite depth (the mixing depth, Z).

Table A-3.10. Aboveground Produce Concentration Due to Direct Deposition

Subsistence Farmer Exposure Scenario

$$Pd_{SF} = \frac{1000 \; x \; Q \; x \; (1 - F_v) \; x \; [Dydp_{SF} + (Fw \; x \; Dywp_{SF})] \; x \; Rp \; x \; [(1.0 - \exp(-kp \; x \; Tp)]}{Yp \; x \; kp}$$

Parameter	Definition	Central Tendency	High End
Pd_{SF}	Concentration in plant due to direct deposition (mg/kg) - Subsistence Farmer		
1000	Units conversion factor (mg/g)		
Q	Emissions (g)	Waste mgt. scenario-specific	
F_v	Fraction of air concentration in vapor phase (dimensionless)	Chemical-specific (see Appendix F of Background Document)	
$Dydp_{SF}$	Normalized yearly dry deposition from particle phase (s/m^2-yr)	Modeled (see Appendix B of Background Document)	
Fw	Fraction of wet deposition that adheres to plant (dimensionless)	Chemical-specific (see Appendix F of Background Document)	
$Dywp_{SF}$	Yearly particle phase wet deposition rate ($g/m^2/yr$)	Modeled (see Appendix B of Background Document)	
Rp	Interception fraction of edible portion of plant (dimensionless) - aboveground vegetable - forage - root vegetable	 0.04 0.5	
kp	Plant surface loss coefficient (1/yr)	18	
Tp	Length of plant exposure to deposition of edible portion of plant, per harvest (yrs) - grain, root vegetable and aboveground vegetable - forage	0.16 0.12	
Yp	Yield or standing crop biomass of the edible portion of the plant (kg DW/m^2) - grain - root vegetable - aboveground vegetable - forage	 0.3 0.09 1.74 0.24	 0.14 0.09

Description

This equation calculates the constituent concentration in aboveground vegetation due to wet and dry deposition of constituent on the plant surface.

Table A-3.11. Aboveground Produce Concentration Due to Air-to-Plant Transfer

Subsistence Farmer Exposure Scenario

$$Pv_{SF} = Q \times F_v \times \frac{Cyv_{SF} \times Bv \times VG_{ag}}{\rho_a}$$

Parameter	Definition	Default Value
Pv_{SF}	Concentration of constituent in the plant due to air-to-plant transfer (mg/kg) - Subsistence Farmer	
Q	Emissions (g)	Waste mgt. scenario-specific
F_v	Fraction of air concentration in vapor phase (dimensionless)	Chemical-specific (see Appendix F of Background Document)
Cyv_{SF}	Normalized vapor phase air concentration (µg-sec/g-m^3)	Modeled (see Appendix B of Background Document)
Bv	Air-to-plant biotransfer factor ([mg constituent/kg plant tissue DW]/[µg constituent/g air])	Chemical-specific (see Appendix F of Background Document)
VG_{ag}	Empirical correction factor for above-ground produce (dimensionless)	0.01
ρ_a	Density of air (g/cm^3)	1.2×10^{-3}

Description

This equation calculates the constituent concentration in aboveground vegetation due to direct uptake of vapor phase chemical into the plant leaves.

Table A-3.12. Aboveground Produce Concentration Due to Root Uptake

Subsistence Farmer Exposure Scenario			
$$Pr_{SF} = C_{SF} \times Br$$			
Parameter	**Definition**	**Central Tendency**	**High End**
Pr_{SF}	Concentration of constituent in the plant due to direct uptake from soil (mg/kg) - Subsistence Farmer		
C_{SF}	Average soil concentration of constituent over exposure duration (mg/kg)	Calculated (see Table A-3.1.)	
Br	Plant-soil bioconcentration factor for aboveground produce [µg/g DW]/[µg/g soil]	Chemical-specific (see Appendix F of Background Document)	
Description			
This equation calculates the constituent concentration in aboveground vegetation due to direct uptake of chemicals from soil.			

Table A-3.13. Root Vegetable Concentration Due to Root Uptake

Subsistence Farmer Exposure Scenario

$$Pr_{bg,SF} = \frac{C_{SF} \ x \ RCF}{Kd_s}$$

Parameter	Definition	Central Tendency	High End
$Pr_{bg,SF}$	Concentration of constituent in belowground plant parts due to root uptake (mg/kg) - Subsistence Farmer		
C_{SF}	Soil concentration of constituent (mg/kg)	Calculated (see Table A-3.1.)	
RCF	Ratio of concentration in roots to concentration in soil pore water ([mg constituent/kg plant tissue FW] / [μg constituent/mL pore water])	Chemical-specific (see Appendix F of Background Document)	
Kd_s	Soil-water partition coefficient (mL/g)	Chemical-specific (see Appendix F of Background Document)	

Description

This equation calculates the constituent concentration in root vegetables due to uptake from the soil water.

Table A-3.14. Beef Concentration Due to Plant and Soil Ingestion

Subsistence Farmer Scenario			
$A_{beef} = (F \times Qp \times P + Qs \times C_{SF}) \times Ba_{beef}$			
Parameter	**Definition**	**Central Tendency**	**High End**
A_{beef}	Concentration of constituent in beef (mg/kg)		
F	Fraction of plant grown on contaminated soil and eaten by the animal grain or forage (dimensionless)	1	
Qp	Quantity of plant eaten by the animal each day (kg plant tissue DW/day) - beef cattle–grain - beef cattle–forage	 0.47 8.8	
P	Total concentration of constituent in the plant eaten by the animal (mg/kg) = Pd + Pv + Pr	Calculated (see Tables A-3.16, A-3.17, A-3.18)	
Qs	Quantity of soil eaten by the foraging animal (kg soil/day)	0.5	
C_{SF}	Soil concentration (mg/kg)	Calculated (see Table A-3.1)	
Ba_{beef}	Biotransfer factor for beef (d/kg)	Chemical-specific (see Appendix F of Background Document)	
Description			
This equation calculates the concentration of constituent in beef from ingestion of forage and soil.			

Table A-3.15. Milk Concentration Due to Plant and Soil Ingestion

Subsistence Farmer Scenario			
$A_{milk} = (F \times Qp \times P + Qs \times C_{SF}) \times Ba_{milk}$			
Parameter	**Definition**	**Central Tendency**	**High End**
A_{milk}	Concentration of constituent in milk (mg/kg)		
F	Fraction of plant grown on contaminated soil and eaten by the animal grain or forage (dimensionless)	1	
Qp	Quantity of plant eaten by the animal each day (kg plant tissue DW/day) - dairy cattle–grain - dairy cattle–forage	 3 13.2	
P	Total concentration of constituent in the plant eaten by the animal (mg/kg) = Pd + Pv + Pr	Calculated (see Tables A-3.16., A-3.17., A-3.18.)	
Qs	Quantity of soil eaten by the foraging animal (kg soil/day)	0.4	
C_{SF}	Soil concentration (mg/kg)	Calculated (see Table A-3.1.)	
Ba_{milk}	Biotransfer factor for milk (day/kg)	Chemical-specific (see Appendix F)	
Description			
This equation calculates the concentration of constituent in milk from ingestion of forage and soil.			

Table A-3.16. Forage (Pasture Grass/Hay) Concentration Due to Direct Deposition

Subsistence Farmer Scenario

$$Pd = \frac{1000 \ x \ Q \ x \ (1 - F_v)[Dydp_{SF} + (Fw \ x \ Dywp_{SF})] \ x \ Rp \ x \ [(1.0 - \exp(-kp \ x \ Tp)]}{Yp \ x \ kp}$$

Parameter	Definition	Central Tendency	High End
Pd	Concentration in plant due to direct deposition (mg/kg)		
1000	Units conversion factor (mg/g)		
Q	Emissions (g/s)	Waste mgt. scenario-specific	
F_v	Fraction of constituent air concentration present in the vapor phase (dimensionless)	Modeled (see Appendix B of Background Document)	
$Dydp_{SF}$	Normalized yearly dry deposition from particle phase (s/m^2-yr)	Modeled (see Appendix B of Background Document)	
Fw	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	Chemical-specific (see Appendix F of Background Document)	
$Dywp_{SF}$	Yearly particle phase wet deposition rate (g/m^2/yr)	Modeled (see Appendix B of Background Document)	
Rp	Interception fraction of edible portion of plant (dimensionless) - aboveground vegetable - forage	0.04 0.5	
kp	Plant surface loss coefficient (1/yr)	18	
Tp	Length of the plant exposure to deposition of edible portion of plant per harvest (yrs) - grain, root vegetable and aboveground vegetable - forage	0.16 0.12	
Yp	Yield or standing crop biomass of the edible portion of the plant (kg DW/m^2) - grain - root vegetable	0.3 0.09	0.14 0.09
	- above-ground vegetable - forage	1.74 0.24	

Description

This equation calculates the constituent concentration in aboveground vegetation due to wet and dry deposition of constituent on the plant surface.

Table A-3.17. Forage (Pasture Grass/Hay) Concentration Due to Air-to-Plant Transfer

Subsistence Farmer Scenario

$$Pv = \frac{Cyv_{SF} \times Bv \times VG_{ag}}{\rho_a}$$

Parameter	Definition	Central Tendency	High End
Pv	Concentration of constituent in the plant due to air-to-plant transfer (mg/kg)		
Cyv_{SF}	Vapor phase air concentration of constituent in air due to direct emissions (μg constituent/m^3)	Modeled (see Appendix C of Background Document)	
Bv	Air-to-plant biotransfer factor ([mg constituent/kg plant tissue DW]/[μg [constituent/g air])	Chemical-specific (see Appendix F of Background Document)	
VG_{ag}	Empirical correction factor that reduces produce concentration because Bv was developed for azalea leaves.	1.0	
ρ_a	Density of air (g/cm^3)	1.2×10^{-3}	

Description

This equation calculates the constituent concentration in aboveground vegetation due to direct uptake of vapor phase chemicals into the plant leaves.

Table A-3.18. Forage/Silage/Grain Concentration Due to Root Uptake

Subsistence Farmer Scenario		
$$Pr = \sum_i C_{SF} \times Br_i$$		
Parameter	**Definition**	**Default Value**
Pr	Concentration of constituent in the plant due to direct uptake from soil (mg/kg)	
C_{SF}	Average soil concentration of constituent over exposure duration (mg/kg)	Calculated (see Table A-3.1.)
Br_i	Plant-soil bioconcentration factor plant species i (forage/silage/grain) [µg/g DW]/[µg/g soil]	Chemical-specific (see Appendix F of Background Document)
Description		
This equation calculates the constituent concentration in aboveground vegetation due to direct uptake of constituents from soil.		

Table A-4.1. Watershed Constituent Concentration

All Exposure Scenarios			
$$C_{WS} = \frac{Ds_{(1)WS}}{ks_{ws}}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
C_{WS}	Constituent concentration in watershed area outside of sub-basin (mg/kg)		
$Ds_{(1),WS}$	Deposition term for the watershed (mg/kg-yr)	Calculated (see Equation A-4.2.)	
ks_{WS}	Constituent loss constant from the watershed (1/yr)	Calculated (see Equation A-4.3.)	
Description			
This equation is used to calculate the mass of constituent deposited onto the watershed area outside of sub-basin as a result of air deposition.			

Table A-4.2. Deposition Rate Factor to Watershed from Source

All Exposure Scenarios

$$Ds_{(1)WS} = \frac{100 \, x \, Q}{Z_{WS} \, x \, BD} \; [F_v \; (Vdv_{WS} \;\; x \;\; Cyv_{WS} \; x \; 10^{-6}) + (Dydp_{WS} \; + \; Dywp_{WS}) \; x \;\; (1 - F_v)]$$

Parameter	Definition	Central	High End
$Ds_{(1)WS}$	Deposition rate factor for the watershed (mg/kg-yr)		
100	Units conversion factor ([mg-m^2]/[kg-cm^2])		
Q	Source emissions (g/m^2-s)	Waste management scenario specific	
Z_{WS}	Soil mixing depth in general watershed area (cm)	2.5	
BD	Soil bulk density (g/cm^3)	1.5	
F_v	Fraction of air concentration in vapor phase (dimensionless)	Chemical specific (see Appendix F of Background Document)	
10^{-6}	Units conversion factor (g/µg)		
Vdv_{WS}	Gas phase mass transfer to soil (m/yr)	31,500	
Cyv_{WS}	Normalized vapor phase air concentration for watershed (µg-s/m-g)	Modeled (see Appendix C of Background Document)	
$Dywv_{WS}$	Normalized yearly wet deposition from vapor phase for watershed (s/yr)	Modeled (see Appendix C of Background Document)	
$Dydp_{WS}$	Normalized yearly dry deposition from particle phase for watershed (s/yr)	Modeled (see Appendix C of Background Document)	
$Dywp_{WS}$	Normalized yearly wet deposition from particle phase for watershed (s/yr)	Modeled (see Appendix C of Background Document)	

Description

These equations calculate average air deposition occurring over the exposure duration as a result of wet and dry deposition of particles onto soil, deposition of wet vapors to soil, and diffusion of dry vapors to soil. Constituents are assumed to be incorporated only to a finite depth (the mixing depth, Z).

Table A-4.3. Constituent Loss Constant

All Exposure Scenarios			
$ks_{WS} = ksl_{WS} + kse_{WS} + ksr_{WS} + ksg_{WS} + ksv_{WS}$			
Parameter	**Definition**	**Central Tendency**	**High End**
ks_{WS}	Constituent loss constant due to all processes from watershed (1/yr)		
ksl_{WS}	Constituent loss constant for watershed due to leaching (1/yr)	Calculated (see Table A-4.4.)	
kse_{WS}	Constituent loss constant for watershed due to soil erosion (1/yr)	Calculated (see Table A-4.5.)	
ksr_{WS}	Constituent loss constant for watershed due to surface runoff (1/yr)	Calculated (see Table A-4.8.)	
ksg_{WS}	Constituent loss constant for watershed due to degradation (1/yr)	Chemical specific (see Appendix F of Background Document)	
ksv_{WS}	Constituent constant for watershed due to volatilization (1/yr)	Calculated (see Table A-4.9.)	
Description			
This equation calculates the constituent loss constant, which accounts for the loss of constituent from soil by several mechanisms.			

Table A-4.4. Constituent Loss Constant due to Leaching

All Exposure Scenarios			
$$ksl_{WS} = \frac{P + I - R - E_v}{\theta \; x \; Z_{WS} \; x \; [1.0 + (BD \; x \; Kd_s / \theta)]}$$			
		Input Value	
Parameter	**Definition**	**Houston**	**LA**
$ksl_{,WS}$	Constituent loss constant for watershed due to leaching (1/yr)		
P	Average annual precipitation (cm/yr)	119.1	28.7
I	Average annual irrigation (cm/yr)	0	0
R	Average annual runoff (cm/yr)	13	1.3
E_v	Average annual evapotranspiration (cm/yr)	22.7	7.3
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
Z_{WS}	Soil depth for watershed from which leaching removal occurs – untilled (cm)	2.5	
BD	Soil bulk density (g/cm^3)	1.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical specific (see Appendix F of Background Document)	
Description			
This equation calculates the constituent loss constant due to leaching from soil.			

Table A-4.5. Constituent Loss Constant Due to Erosion

All Exposure Scenarios

$$kse_{WS} = \frac{0.1 \ x \ X_{e,WS} \ x \ SD_{WS} \ x \ ER}{BD \ x \ Z_{WS}} \ x \ \left(\frac{Kd_s \ x \ BD}{\theta + (Kd_s \ x \ BD)} \right)$$

Parameter	Definition	Central Tendency	High End
kse_{WS}	Constituent loss constant due to erosion for watershed (1/yr)		
$X_{e,WS}$	Unit soil loss for watershed (kg/m^2/yr)	Calculated (see Table A-4.6.)	
SD_{WS}	Sediment delivery ratio for watershed (unitless)	Calculated (see Table A-4.7.)	
ER	Constituent enrichment ratio (unitless)	Organics = 3 Metals = 1	
BD	Soil bulk density (g/cm^3)	1.5	
Z_{WS}	Soil mixing depth in watershed – untilled (cm)	2.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical specific (see Appendix F of Background Document)	
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
0.1	Units conversion factor (g-m^2)/(kg-cm^2)		

Description

This equation calculates the constituent loss constant due to runoff from soil.

Table A-4.6. Universal Soil Loss Equation (USLE) for the Watershed

All Exposure Scenarios

$$X_{e,WS} = R_{WS} \times K_{WS} \times LS_{WS} \times C_{WS} \times P_{WS} \times \frac{907.18}{4,047}$$

Parameter	Definition	Central Tendency	High End
$X_{e,WS}$	Unit soil loss from the watershed (kg/m^2 -yr)		
R_{WS}	USLE rainfall factor (1/yr)	428	50
K_{WS}	USLE erodibility factor (ton/acre)	0.37	
LS_{WS}	USLE length-slope factor (unitless)	1.5	
C_{WS}	USLE cover factor (unitless)	0.1	
P_{WS}	USLE erosion control practice factor (unitless)	1.0	
907.18	Units conversion factor (kg/ton)		
4,047	Units conversion factor (m^2/acre)		

Description

This equation is used to calculate the soil loss rate from the watershed using the Universal Soil Loss Equation.

Table A-4.7. Sediment Delivery Ratio

Subsistence Fisher Scenario			
$$SD_{WS} = a \times (A_{WS})^{-b}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
SD_{WS}	Sediment delivery ratio for watershed (unitless)		
a	Empirical intercept coefficient	Depends on watershed area; see table below	
A_{WS}	Watershed area receiving fallout (m^2)	2.93×10^9	
b	Empirical slope coefficient	0.125	
Description			
This equation calculates the sediment delivery ratio for the watershed.			

Values for Empirical Intercept Coefficient, a

Watershed area (sq. miles)	"a" coefficient (unitless)
≤ 0.1	2.1
1	1.9
10	1.4
100	1.2
1,000	0.6
1 sq. mile = 2.59×10^6 m^2	

Table A-4.8. Constituent Loss Constant Due to Runoff

All Exposure Scenarios			
$$ksr_{WS} = \frac{R}{\theta \ x \ Z_{WS}} \ x \left(\frac{1}{1 + (Kd_s \ x \ BD/\theta)} \right)$$			
Parameter	**Definition**	**Central Tendency**	**High End**
ksr_{WS}	Constituent loss constant due to runoff for watershed (1/yr)		
R	Average annual runoff (cm/yr)	13	1.3
θ	Soil volumetric water content (mL/cm^3)	Calculated (see Table A-1.17.)	
Z_{WS}	Soil mixing depth in watershed – untilled (cm)	2.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (see Appendix F of Background Document)	
BD	Soil bulk density (g/cm^3)	1.5	
Description			
This equation calculates the constituent loss constant due to runoff from soil.			

Table A-4.9. Constituent Loss Constant Due to Volatilization

All Exposure Scenarios

$$ksv_{WS} = \left[\frac{3.1536x10^{7}\ x\ H}{Z_{WS}\ x\ Kd_s\ x\ R\ x\ T\ x\ BD}\right] x \left[0.482\ x\ u^{0.78}\ x \left(\frac{\mu_a}{\rho_a\ x\ D_a}\right)^{-0.67} x \left(\sqrt{\frac{4\ x\ A_{WS}}{\pi}}\right)^{-0.11}\right]$$

Parameter	Definition	Central Tendency	High End
ksv_{WS}	Constituent loss constant due to volatilization for watershed (1/yr)		
$3.1536x10^7$	Conversion constant (s/yr)		
H	Henry's law constant (atm-m^3/mol)	Chemical specific (see Appendix F of Background Document)	
Z_{WS}	Soil mixing depth in watershed – untilled (cm)	2.5	
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical specific (see Appendix F of Background Document)	
R	Universal gas constant (atm-m^3/mol-K)	$8.205x10^{-5}$	
T	Ambient air temperature (K)	294	290
BD	Soil bulk density (g/cm^3)	1.5	
u	Average annual windspeed (m/s)	4.1	4.1
μ_a	Viscosity of air (g/cm-s)	$1.81x10^{-4}$	
ρ_a	Density of air (g/cm^3)	$1.2x10^{-3}$	
D_a	Diffusivity of constituent in air (cm^2/s)	Chemical specific (see Appendix F of Background Document)	
A_{WS}	Total watershed surface area (m^2)	$2.93x10^9$	

Description

This equation calculates the constituent loss constant due to volatilization from soil.

Table A-4.10. Total Waterbody Load

Subsistence Fisher Scenario			
$$L_T = L_{Dep} + L_{Dif} + L_{RI} + L_R + L_E$$			
Parameter	**Definition**	**Central Tendency**	**High End**
L_T	Total constituent load to the waterbody (g/yr)		
L_{Dep}	Total (wet and dry) particle phase and wet vapor phase direct deposition load to waterbody (g/yr)	Calculated (see Table A-4.11.)	
L_{Dif}	Vapor phase constituent diffusion (dry deposition) load to waterbody (g/yr)	Calculated (see Table A-4.12.)	
L_{RI}	Runoff load from impervious surfaces (g/yr)	Calculated (see Table A-4.16.)	
L_R	Runoff load from pervious surfaces (g/yr)	Calculated (see Table A-4.17.)	
L_E	Soil erosion load (g/yr)	Calculated (see Table A-4.19.)	
Description			
This equation calculates the total average waterbody load from wet and dry vapor and particle deposition, runoff, and erosion loads.			

Table A-4.11. Deposition to Waterbody

Subsistence Fisher Scenario			
$L_{Dep} = Q \times [F_v \times Dywwv + (1 - F_v) \times Dytwp] \times WA_w$			
Parameter	**Definition**	**Central Tendency**	**High End**
L_{Dep}	Total (wet and dry) particle phase and wet vapor phase direct deposition load to waterbody (g/yr)		
Q	Source emissions (g/m^2-s)	Waste management scenario-specific	
F_v	Fraction of air in vapor phase (dimensionless)	Chemical specific (see Appendix F of Background Document)	
Dywwv	Normalized yearly waterbody average wet deposition from vapor phase (s/yr)	Modeled (see Appendix C of Background Document)	
Dytwp	Normalized yearly waterbody average total (wet and dry) deposition from particle phase (s/yr)	Modeled (see Appendix C of Background Document)	
WA_w	Waterbody area (m^2)	1.0×10^6	
Description			
This equation calculates the average load to the waterbody from direct deposition of wet and dry particles and wet vapors onto the surface of the waterbody.			

Table A-4.12. Diffusion Load to Waterbody

Subsistence Fisher Scenario			
$$L_{Dif} = \frac{K_v \times Q \times F_v \times Cywv \times WA_w \times 10^{-6}}{\frac{H}{R \times T_w}}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
L_{Dif}	Dry vapor phase constituent diffusion load to waterbody (g/yr)		
K_v	Diffusive mass transfer coefficient (m/yr)	Calculated (see Table A-4.13.)	
Q	Source emissions (g/m^2-s)	Waste management scenario specific	
F_v	Fraction of air concentration in vapor phase (dimensionless)	Chemical specific (see Appendix F of Background Document)	
Cywv	Normalized yearly waterbody average vapor phase air concentration (mg-s/g-m)	Modeled (see Appendix C of Background Document)	
WA_w	Waterbody surface area (m^2)	1.0×10^6	
10^{-6}	Units conversion factor (g/µg)		
H	Henry's law constant (atm-m^3/mol)	Chemical specific (see Appendix F of Background Document)	
R	Universal gas constant (atm-m^3/mol-K)	8.205×10^{-5}	
T_w	Waterbody temperature (K)	298	
Description			
This equation calculates the load to the waterbody due to vapor diffusion.			

Table A-4.13. Overall Transfer Rate

Subsistence Fisher Scenario			
$$K_v = \left[K_L^{-1} + \left(K_G \frac{H}{R \; x \; T_k}\right)^{-1}\right]^{-1} \; x \; \theta^{(T_k - 293)}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
K_v	Overall transfer rate (m/yr)		
K_L	Liquid phase transfer coefficient (m/yr)	Calculated (see Table A-4.14.)	
K_G	Gas phase transfer coefficient (m/yr)	Calculated (see Table A-4.15.)	
H	Henry's Law constant (atm-m^3/mol)	Chemical specific (see Appendix F of Background Document)	
R	Universal gas constant (atm-m^3/mol-K)	8.205×10^{-5}	
T_k	Waterbody temperature (K)	298	
θ	Temperature correction factor (unitless)	1.026	
Description			
This equation calculates the overall transfer rate of constituent from the liquid and gas phases in surface water.			

Table A-4.14. Liquid Phase Transfer Coefficient

<table>
<tr><th colspan="4">Subsistence Fisher Scenario</th></tr>
<tr><td colspan="4">- Flowing stream or river
- Quiescent lake or pond
$$K_L = \sqrt{\frac{10^{-4} \ x \ D_w \ x \ u}{d_z}} \ x \ 3.15 \ x \ 10^7$$
$$K_L = (C_d^{0.5} \ x \ W) \ x \left(\frac{\rho_a}{\rho_w}\right)^{0.5} x \left(\frac{k^{0.33}}{\lambda_2}\right) x \left(\frac{\mu_w}{\rho_w \ x \ D_w}\right)^{-0.67} x \ 3.15x10^7$$
$$\rho_w = 1 - 8.8 \ x \ 10^{-5} \ x \ (T_k - 273)$$</td></tr>
<tr><th>Parameter</th><th>Definition</th><th>Central Tendency</th><th>High End</th></tr>
<tr><td>K_L</td><td>Liquid phase transfer coefficient (m/yr)</td><td colspan="2"></td></tr>
<tr><td>D_w</td><td>Diffusivity of chemical in water (cm^2/s)</td><td colspan="2">Chemical specific
(see Appendix F of Background Document)</td></tr>
<tr><td>u</td><td>Current velocity (m/s)</td><td colspan="2">0.7</td></tr>
<tr><td>d_z</td><td>Total waterbody depth (m)</td><td colspan="2">Calculated (d_w+d_b)</td></tr>
<tr><td>C_d</td><td>Drag coefficient (unitless)</td><td colspan="2">0.0011</td></tr>
<tr><td>W</td><td>Wind velocity, 10 m above water surface (m/s)</td><td>4.1</td><td>4.1</td></tr>
<tr><td>ρ_a</td><td>Density of air corresponding to water temperature (g/cm^3)</td><td colspan="2">1.2×10^{-3}</td></tr>
<tr><td>ρ_w</td><td>Density of water corresponding to water temperature (g/cm^3)</td><td colspan="2">Calculated</td></tr>
<tr><td>k</td><td>von Karman's constant (unitless)</td><td colspan="2">0.4</td></tr>
<tr><td>λ_2</td><td>Dimensionless viscous sublayer thickness</td><td colspan="2">4</td></tr>
<tr><td>μ_w</td><td>Viscosity of water corresponding to the water temperature (g/cm-s)</td><td colspan="2">1.69×10^{-2}</td></tr>
<tr><td>$3.15x10^7$</td><td>Conversion constant (s/yr)</td><td colspan="2"></td></tr>
<tr><td>10^{-4}</td><td>Units conversion factor (m^2/cm^2)</td><td colspan="2"></td></tr>
<tr><td>T_K</td><td>Waterbody temperature (K)</td><td colspan="2">298</td></tr>
<tr><th colspan="4">Description</th></tr>
<tr><td colspan="4">This equation calculates the transfer rate of constituent from the liquid phase for a flowing or quiescent system.</td></tr>
</table>

Table A-4.15. Gas Phase Transfer Coefficient

<table>
<tr><th colspan="4">Subsistence Fisher Scenario</th></tr>
<tr><td colspan="4">- Flowing stream or river
$$K_G = 36500\ m/yr$$
- Quiescent lake or pond
$$K_G = (C_d^{0.5}\ x\ W)\ x\ \left(\frac{k^{0.33}}{\lambda_2}\right)\ x\ \left(\frac{\mu_a}{\rho_a\ x\ D_a}\right)^{-0.67}\ x\ 3.15x10^7$$</td></tr>
<tr><th>Parameter</th><th>Definition</th><th>Central Tendency</th><th>High End</th></tr>
<tr><td>K_G</td><td>Gas phase transfer coefficient (m/yr)</td><td colspan="2"></td></tr>
<tr><td>C_d</td><td>Drag coefficient (unitless)</td><td colspan="2">0.0011</td></tr>
<tr><td>W</td><td>Wind velocity, 10 m above water surface (m/s)</td><td>4.1</td><td>4.1</td></tr>
<tr><td>k</td><td>von Karman's constant (unitless)</td><td colspan="2">0.4</td></tr>
<tr><td>λ_2</td><td>Dimensionless viscous sublayer thickness (unitless)</td><td colspan="2">4</td></tr>
<tr><td>μ_a</td><td>Viscosity of air corresponding to the air temperature (g/cm-s)</td><td colspan="2">1.81×10^{-4}</td></tr>
<tr><td>ρ_a</td><td>Density of air corresponding to water temperature (g/cm^3)</td><td colspan="2">1.2×10^{-3}</td></tr>
<tr><td>D_a</td><td>Diffusivity of chemical in air (cm^2/s)</td><td colspan="2">Chemical specific
(see Appendix F of Background Document)</td></tr>
<tr><td>$3.15x10^7$</td><td>Conversion constant (s/yr)</td><td colspan="2"></td></tr>
<tr><th colspan="4">Description</th></tr>
<tr><td colspan="4">This equation calculates the transfer rate of constituent from the gas phase for a flowing or quiescent system.</td></tr>
</table>

Table A-4.16. Impervious Runoff Load to Waterbody

Subsistence Fisher Scenario			
$$L_{RI} = Q \; x \; [\, F_v \; x \; Dywwv + (1.0 - F_v) \; x \; Dytwp \,] \; x \; A_I$$			
Parameter	**Definition**	**Central Tendency**	**High End**
L_{RI}	Impervious surface runoff load (g/yr)		
A_I	Impervious watershed area receiving pollutant deposition (m^2)	2.05×10^9	
Q	Source emissions (g/m^2-s)	Waste mgt. scenario specific	
F_v	Fraction of air concentration in vapor phase (dimensionless)	Chemical specific (see Appendix F of Background Document)	
Dywwv	Normalized yearly watershed average wet deposition from vapor phase (s/yr)	Modeled (see Appendix B of Background Document)	
Dytwp	Normalized yearly watershed average total (wet and dry) deposition from particle phase (s/yr)	Modeled (see Appendix B of Background Document)	
Description			
This equation calculates the average runoff load to the waterbody from impervious surfaces in the watershed from which runoff is conveyed directly to the waterbody.			

Table A-4.17. Pervious Runoff Load to Waterbody

Subsistence Fisher Scenario			
$$L_R = R \; x \; (A_{WS} - A_I) \; x \; \frac{S_C \; x \; BD}{\theta + Kd_s \; x \; BD} \; x \; 0.01$$			
Parameter	**Definition**	**Central Tendency**	**High End**
L_R	Pervious surface runoff load (g/yr)		
R	Average annual surface runoff (cm/yr)	13	1.3
S_c	Weighted average constituent concentration in total watershed soils (watershed and sub-basin) based on surface area (mg/kg)	Calculated (see Table A-4.18.)	
BD	Soil bulk density (g/cm^3)	1.5	
Kd_s	Soil-water partition coefficient (L/kg) or (cm^3/g)	Chemical specific (see Appendix F of Background Document)	
A_{WS}	Total watershed area (m^2)	$2.93x10^9$	
A_I	Impervious watershed area receiving constituent deposition (m^2)	$2.05x10^9$	
0.01	Units conversion factor ($kg\text{-}cm^2/mg\text{-}m^2$)		
θ	Volumetric soil water content (cm^3/cm^3)	Calculated (see Table A-1.17.)	
Description			
This equation calculates the average runoff load to the waterbody from pervious soil surfaces in the watershed.			

Table A-4.18. Constituent Concentration in Total Watershed Soils Based on Surface Area

All Exposure Scenarios

$$S_C = \frac{A_S \, x \, C_0 + A_F \, x \, C_R + A_{B/Surr} \, x \, C_{B/Surr} + (A_{WS} - A_S - A_{B/Surr} - A_F) \, x \, C_{WS}}{A_{WS}}$$

Parameter	Definition	Central Tendency	High End
S_C	Weighted average constituent concentration in total watershed soils (watershed and sub-basin soils) based on surface area (mg/kg)		
A_S	Area of source (m^2)	Waste management scenario specific	
C_0	Source constituent concentration (mg/kg)	Chemical specific	
A_F	Area of residential plot (m^2)	5,100	
C_R	Constituent concentration in residential plot - Adult resident (mg/kg)	Calculated (see Table A-1.1.)	
$A_{B/Surr}$	Area of buffer and surrounding areas (m^2)	Calculated (see Table A-1.5.)	
$C_{B/Surr}$	Buffer and surrounding area constituent concentration (mg/kg)	Calculated (see Table A-1.11.)	
A_{WS}	Area of entire watershed (m^2)	$2.93x10^9$	
C_{WS}	Watershed constituent concentration (mg/kg)	Calculated (see Table A-4.1.)	

Description

This equation is used to calculate the weighted average constituent concentration in the total watershed soils, using the constituent concentration in the watershed soils and the constituent concentration in each of the areas within the sub-basin (e.g., source, residential plot, and buffer and surrounding area).

Table A-4.19. Erosion Load to Waterbody

Subsistence Fisher Scenario

$$L_E = X_{e,ws} \ x \ (A_{WS} - A_I) \ x \ SD_{WS} \ x \ ER \ x \ \frac{S_{c,soil} \ x \ Kd_s \ x \ BD}{\theta + Kd_s \ x \ BD} \ x \ 0.001$$

Parameter	Definition	Central Tendency	High End
L_E	Constituent load via soil erosion load (g/yr)		
$X_{e,WS}$	Unit soil loss from the watershed (kg/m^2/yr)	Calculated (see Table A-4.6)	
$S_{c,soil}$	Weighted average total watershed soil (watershed and sub-basin) concentration based on sediment transport (mg/kg)	Calculated (see Table A-4.20.)	
BD	Soil bulk density (g/cm^3)	1.5	
θ	Volumetric soil water content (cm^3/cm^3)	Calculated (see Table A-1.17)	
Kd_s	Soil-water partition coefficient (L/kg) or (cm^3/g)	Chemical specific (see Appendix F of Background Document)	
A_{WS}	Total watershed area (m^2)	2.93×10^9	
A_I	Impervious watershed area (m^2)	2.05×10^9	
SD_{WS}	Sediment delivery ratio for watershed (unitless)	Calculated (see Table A-4.7.)	
ER	Soil enrichment ratio (unitless)	Organics = 3 Metals = 1	
0.001	Units conversion factor (g/mg)		

Description

This equation calculates the load to the waterbody from soil erosion.

Table A-4.20. Weighted Average Soil Concentration Based on Eroded Soil Contributions

All Exposure Scenarios
$$S_{c,soil} = \left[\frac{(X_{e,S} \times A_S \times C_0 \times SD_{SB}) + (X_{e,B/Surr} \times A_{B/Surr} \times C_{B/Surr} \times SD_{SB}) + (X_{e,R} \times A_F \times C_R \times SD_{SB})}{X_{e,WS} \times A_{WS} \times SD_{WS}}\right] + \frac{(A_{ws} - A_s - A_{B/Surr} - A_F) \times C_{ws}}{A_{ws}}$$

Parameter	Definition	Input Value
$S_{c,\,soil}$	Weighted average total watershed soil (watershed and sub-basin) concentration based on eroded soil transport (mg/kg)	
$X_{e,s}$	Unit soil loss from source (kg/m^2/yr)	Calculated (see Table A-1.3.)
A_S	Source area (m^2)	Waste management scenario specific
C_0	Source constituent concentration (mg/kg)	Constituent specific
SD_{SB}	Sediment delivery ratio for sub-basin (unitless)	Calculated (see Table A-1.4.)
$X_{e,B/Surr}$	Unit soil loss from buffer and surrounding areas (kg/m^2/yr)	Calculated (see Table A-1.20.)
$A_{B/Surr}$	Buffer and surrounding areas (m^2)	Calculated (see Table A-1.5.)
$C_{B/Surr}$	Buffer and surrounding areas constituent concentration (mg/kg)	Calculated (see Table A-1.11.)
$X_{e,R}$	Unit soil loss from field (kg/m^2/yr)	Calculated (see Table A-1.28.)
A_F	Area of residential plot (m^2)	5,100
C_R	Constituent concentration in residential plot (mg/kg)	Calculated (see Table A-1.1.)
$X_{e,WS}$	Unit soil loss from the watershed (kg/m^2/yr)	Calculated (see Table A-4.6.)
A_{WS}	Total watershed area (m^2)	2.93×10^9
SD_{WS}	Sediment delivery ratio for watershed (unitless)	Calculated (see Table A-4.7.)
C_{WS}	Watershed constituent concentration (mg/kg)	Calculated (see Table A-4.1.)

Description
This equation calculates the average concentration of delivered sediment for the watershed allowing for different unit soil loss factors and sediment delivery ratios for each of the modeled areas.

Table A-4.21. Total Waterbody Concentration

Subsistence Fisher Scenario		
$$C_{wtot} = \frac{L_T}{Vf_x \; x \; f_{water} + k_{wt} \; x \; WA_w \; x \; (d_w + d_b)}$$		
Parameter	**Definition**	**Input Value**
C_{wtot}	Total water body concentration, including water column and bed sediment (mg/L) or (g/(m^3)	
L_T	Total chemical load into water-body, including deposition, runoff, and erosion (g/yr)	Calculated (see Table A-4.10.)
Vf_x	Average volumetric flow rate through water body (m^3/yr)	$3x10^8$
f_{water}	Fraction of total water body constituent concentration that occurs in the water column (unitless)	Calculated (see Table A-4.22.)
k_{wt}	Overall total waterbody dissipation rate constant (1/yr)	Calculated (see Table A-4.23.)
WA_w	Waterbody surface area (m^2)	$1.0x10^6$
d_w	Depth of water column (m)	0.64
d_b	Depth of upper benthic layer (m)	0.03
Description		
This equation calculates the total waterbody concentration, including both the water column and the bed sediment.		

Table A-4.22. Fraction in Water Column and Benthic Sediment

Subsistence Fisher Scenario			
$$f_{water} = \frac{(1 + Kd_{sw} \times TSS \times 10^{-6}) \times d_w / d_z}{(1 + Kd_{sw} \times TSS \times 10^{-6}) \times d_w/d_z + (\theta_{bs} + Kd_{bs} \times BS) \times d_b / d_z}$$ $$f_{benth} = 1 - f_{water}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
f_{water}	Fraction of total waterbody constituent concentration that occurs in the water column (unitless)		
Kd_{sw}	Suspended sediment/surface water partition coefficient (L/kg)	Chemical specific (see Appendix F of Background Document)	
TSS	Total suspended solids (mg/L)	80	
10^{-6}	Conversion factor (kg/mg)		
d_w	Depth of the water column (m)	0.64	
d_z	Total waterbody depth (m)	Calculated (d_w+d_b)	
d_b	Depth of the upper benthic layer (m)	0.03	
θ_{bs}	Bed sediment porosity (L_{water}/L)	0.6	
Kd_{bs}	Bed sediment/sediment pore water partition coefficient (L/kg) or (g/cm^3)	Chemical-specific (see Appendix F of Background Document)	
BS	Bed sediment concentration (g/cm^3)	1.0	
f_{benth}	Fraction of total waterbody constituent concentration that occurs in the benthic sediment (unitless)		
Description			
These equations calculate the fraction of total waterbody concentration occurring in the water column and the bed sediments.			

Table A-4.23. Overall Total Waterbody Dissipation Rate Constant

Subsistence Fisher Scenario			
$$k_{wt} = f_{water} \times k_v + k_b$$			
Parameter	**Definition**	**Central Tendency**	**High End**
k_{wt}	Overall total waterbody dissipation rate constant (1/yr)		
f_{water}	Fraction of total waterbody constituent concentration that occurs in the water column	Calculated (see Table A-4.22.)	
k_v	Water column volatilization rate constant (1/yr)	Calculated (see Table A-4.24.)	
k_b	Benthic burial rate constant (1/yr)	Calculated (see Table A-4.25.)	
Description			
This equation calculates the overall dissipation rate of constituent in surface water due to volatilization and benthic burial.			

Table A-4.24. Water Column Volatilization Loss Rate Constant

Subsistence Fisher Scenario			
$$k_v = \frac{K_v}{d_z \times (1 + Kd_{sw} \times TSS \times 10^{-6})}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
k_v	Water column volatilization rate constant (1/yr)		
K_v	Overall transfer rate (m/yr)	Calculated (see Table A-4.13.)	
d_z	Total waterbody depth (m)	Calculated (d_w+d_b)	
Kd_{sw}	Suspended sediment/surface water partition coefficient (L/kg)	Chemical specific (see Appendix F of Background Document)	
TSS	Total suspended solids (mg/L)	80	
10^{-6}	Conversion factor (kg/mg)		
Description			
This equation calculates the water column constituent loss due to volatilization.			

Table A-4.25. Benthic Burial Rate Constant

Subsistence Fisher Scenario			
$$k_b = f_{benth} \ x \ \left(\frac{W_b}{d_b}\right)$$			
Parameter	**Definition**	**Central Tendency**	**High End**
k_b	Benthic burial rate constant (1/yr)		
f_{benth}	Fraction of total waterbody constituent concentration that occurs in the benthic sediment	Calculated (see Table A-4.22)	
W_b	Burial rate (m/yr)	Calculated (see Table A-4.26)	
d_b	Depth of upper benthic sediment layer (m)	0.03	
Description			
This equation calculates the water column constituent loss due to burial in benthic sediment.			

Table A-4.26. Benthic Burial Rate Constant

Subsistence Fisher Scenario			
$$W_b = W_{dep} \times \left(\frac{TSS \times 10^{-6}}{BS} \right)$$			
Parameter	**Definition**	**Central Tendency**	**High End**
W_b	Benthic burial rate constant (m/yr)		
W_{dep}	Deposition rate to bottom sediment (m/yr)	Calculated (see Table A-4.27)	
TSS	Total suspended solids (mg/L)	80	
10^{-6}	Units conversion factor (kg/mg)		
BS	Bed sediments concentration (kg/L)	1	
Description			
This equation is used to determine the loss of constituent from the benthic sediment layer.			

Table A-4.27. Deposition Rate to Bottom Sediment

Subsistence Fisher Scenario			
$$W_{dep} = \left(\frac{X_{e,ws} \ x \ A_{ws} \ x \ SD_{ws} \ x \ 1000 - Vf_x \ x \ TSS}{WA_w \ x \ TSS} \right)$$			
Parameter	**Definition**	**Central Tendency**	**High End**
W_{dep}	Deposition rate to bottom sediment (m/yr)		
$X_{e,ws}$	Unit soil loss from the watershed ($kg/m^2/yr$)	Calculated (see Table A-4.6)	
A_{ws}	Area of watershed (m^2)	2.93×10^9	
SD_{ws}	Watershed sediment delivery ratio (unitless)	Calculated (see Table A-4.7)	
Vf_x	Average volumetric flow rate (m^3/yr)	3.0×10^8	
TSS	Total suspended solids (g/m^3)	80	
1000	Units conversion factor (g/kg)		
WA_w	Waterbody surface area (m^2)	1×10^6	
Description			
This equation is used to determine the loss of constituent from the waterbody as it deposits onto the benthic sediment.			

Table A-4.28. Total Water Column Concentration

Subsistence Fisher Scenario			
$$C_{wt} = f_{water} \ x \ C_{wtot} \ x \ \frac{d_w + d_b}{d_w}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
C_{wt}	Total concentration in water column (mg/L)		
f_{water}	Fraction of total water body constituent concentration that occurs in the water column (unitless)	Calculated (see Table A-4.22.)	
C_{wtot}	Total water concentration in surface water system, including water column and bed sediment (mg/L)	Calculated (see Table A-4.21.)	
d_b	Depth of upper benthic layer (m)	0.03	
d_w	Depth of the water column (m)	0.64	
Description			
This equation calculates the total water column concentration of constituent; this includes both dissolved constituent and constituent sorbed to suspended solids.			

Table A-4.29. Dissolved Water Concentration

Subsistence Fisher Scenario

$$C_{dw} = \frac{C_{wt}}{1 + Kd_{sw} \ x \ TSS \ x \ 10^{-6}}$$

Parameter	Definition	Central Tendency	High End
C_{dw}	Dissolved phase water concentration (mg/L)		
C_{wt}	Total concentration in water column (mg/L)	Calculated (see Table A-4.28.)	
Kd_{sw}	Suspended sediment/surface water partition coefficient (L/kg)	Chemical specific (see Appendix F of Background Document)	
10^{-6}	Units conversion factor (kg/mg)		
TSS	Total suspended solids (mg/L)	80	

Description

This equation calculates the concentration of constituent dissolved in the water column.

Table A-4.30. Concentration Sorbed to Bed Sediment

Subsistence Fisher Scenario			
$$C_{sb} = f_{benth} \; x \; C_{wtot} \; x \; \frac{Kd_{bs}}{\theta_{bs} + Kd_{bs} \; x \; BS} \; x \; \frac{d_w + d_b}{d_b}$$			
Parameter	**Definition**	**Central Tendency**	**High End**
C_{sb}	Concentration sorbed to bed sediments (mg/kg)		
f_{benth}	Fraction of total waterbody constituent concentration that occurs in the bed sediment (unitless)	Calculated (see Table A-4.22.)	
C_{wtot}	Total water concentration in surface water system, including water column and bed sediment (mg/L)	Calculated (see Table A-4.21.)	
d_w	Total depth of water column (m)	0.64	
d_b	Depth of the upper benthic layer (m)	0.03	
θ_{bs}	Bed sediment porosity (unitless)	0.6	
Kd_{bs}	Bed sediment/sediment pore water partition coefficient (L/kg)	Chemical specific (see Appendix F of Background Document)	
BS	Bed sediment concentration (kg/L)	1.0	
Description			
This equation calculates the concentration of constituent sorbed to bed sediments.			

Table A-4.31. Fish Concentration from Dissolved Water Concentration

Subsistence Fisher Scenario			
$C_{fish} = C_{dw} \times BCF$			
Parameter	**Definition**	**Central Tendency**	**High End**
C_{fish}	Fish concentration (mg/kg)		
C_{dw}	Dissolved water concentration (mg/L)	Calculated (see Table A-4.29.)	
BCF	Bioconcentration factor (L/kg)	Chemical specific (see Appendix F of Background Document)	
Description			
This equation calculates fish concentration from dissolved water concentration using a bioconcentration factor.			

Table A-4.32. Fish Concentration from Total Water Column Concentration

Subsistence Fisher Scenario			
$C_{fish} = C_{wt} \times BAF$			
Parameter	**Definition**	**Central Tendency**	**High End**
C_{fish}	Fish concentration (mg/kg)		
C_{wt}	Total water column concentration (mg/L)	Calculated (see Table A-4.28.)	
BAF	Bioaccumulation factor (L/kg)	Chemical specific (see Appendix F of Background Document)	
Description			
This equation calculates fish concentration from total water column concentration using a bioaccumulation factor.			