Calculation of Site Specific Risk Reduction Standards (SSRRSs) Commercial/Industrial Scenario

Equation 4-1
Screening Level Equation for Combined Ingestion and Dermal Absorption Exposure to Carcinogenic Contaminants in Soil - Commercial/Industrial Scenario

$$\text{Screening Level (mg/kg)} = \frac{TR \times BW \times AT \times 365\,d/yr}{(EF \times ED \times 10^{-6} kg/mg)((SF_o \times IR) + (SF_{ABS} \times AF \times ABS_d \times SA \times EV))}$$

Parameter/Definition (units)	Default
TR/target cancer risk (unitless)	10^{-6}
BW/body weight (kg)	70
AT/averaging time (years)	70
EF/exposure frequency (days/year)	
outdoor worker	**225**
indoor worker	250
ED/exposure duration (years)	
outdoor worker	**25**
indoor worker	25
SF_o/oral cancer slope factor $(mg/kg\text{-}d)^{-1}$	chemical-specific (Appendix C)
IR/soil ingestion rate (mg/d)	
outdoor worker	100
indoor worker	50
SF_{ABS}/dermally-adjusted cancer slope factor $(mg/kg\text{-}d)^{-1}$	chemical-specific (Equation 3-3)
AF/skin-soil adherence factor (mg/cm^2-event)	**0.2**
ABS_d/dermal absorption fraction (unitless)	chemical-specific (Exhibit 3-3 and Appendix C)
SA/skin surface exposed (cm^2)	**3,300**
EV/event frequency (events/day)	
outdoor worker	**1**
indoor worker	**0**

Equation 4-2
Screening Level Equation for Combined Ingestion and Dermal Absorption Exposure to Non-Carcinogenic Contaminants in Soil - Commercial/Industrial Scenario

$$\text{Screening Level (mg/kg)} = \frac{THQ \times BW \times AT \times 365\,d/yr}{(EF \times ED \times 10^{-6} kg/mg)\left[\left(\frac{1}{RfD_o} \times IR\right) + \left(\frac{1}{RfD_{ABS}} \times AF \times ABS_d \times SA \times EV\right)\right]}$$

Parameter/Definition (units)	Default
THQ/target hazard quotient (unitless)	1
BW/body weight (kg)	70
AT/averaging time (years)	25[a]
EF/exposure frequency (days/year)	
outdoor worker	**225**
indoor worker	250
ED/exposure duration (years)	
outdoor worker	**25**
indoor worker	25
RfD_o/oral reference dose (mg/kg-d)	chemical-specific (Appendix C)
IR/soil ingestion rate (mg/d)	
outdoor worker	100
indoor worker	50
RfD_{ABS}/dermally-adjusted reference dose (mg/kg-d)	chemical-specific (Equation 3-4)
AF/skin-soil adherence factor (mg/cm^2-event)	**0.2**
ABS_d/dermal absorption fraction (unitless)	chemical-specific (Exhibit 3-3 and Appendix C)
SA/skin surface exposed (cm^2)	**3,300**
EV/event frequency (events/day)	
outdoor worker	**1**
indoor worker	**0**

[a] For non-carcinogens, averaging time equals exposure duration.

Equation 4-3
Screening Level Equation for Inhalation of Carcinogenic Fugitive Dusts - Commercial/Industrial Scenario

$$\text{Screening Level (mg/kg)} = \frac{TR \times AT \times 365\,d/yr}{URF \times 1{,}000\,\mu g/mg \times EF \times ED \times \frac{1}{PEF}}$$

Parameter/Definition (units)	Default
TR/target cancer risk (unitless)	10^{-6}
AT/averaging time (yr)	70
URF/inhalation unit risk factor $(\mu g/m^3)^{-1}$	chemical-specific (Appendix C)
EF/exposure frequency (d/yr)	
Outdoor Worker	**225**
ED/exposure duration (yr)	
Outdoor Worker	**25**
PEF/particulate emission factor (m^3/kg)	**1.36×10^9 (Equation 4-5)**

Equation 4-4
Screening Level Equation for Inhalation of Non-carcinogenic Fugitive Dusts - Commercial/Industrial Scenario

$$\text{Screening Level (mg/kg)} = \frac{THQ \times AT \times 365\,d/yr}{EF \times ED \times [\frac{1}{RfC} \times \frac{1}{PEF}]}$$

Parameter/Definition (units)	Default
THQ/target hazard quotient (unitless)	1
AT/averaging time (yr)	
Outdoor Worker	**25**[a]
EF/exposure frequency (d/yr)	
Outdoor Worker	**225**
ED/exposure duration (yr)	
Outdoor Worker	**25**
RfC/inhalation reference concentration (mg/m^3)	chemical-specific (Appendix C)
PEF/particulate emission factor (m^3/kg)	**1.36×10^9 (Equation 4-5)**

[a] For non-carcinogens, averaging time equals exposure duration.

Equation 4-5
Derivation of the Particulate Emission Factor
- Commercial/Industrial Scenario

$$PEF = Q/C_{wind} \times \frac{3{,}600 s/h}{0.036 \times (1-V) \times (U_m/U_t)^3 \times F(x)}$$

Parameter/Definition (units)	Default
PEF/particulate emission factor (m^3/kg)	1.36×10^9
Q/C_{wind}/inverse of the ratio of the geometric mean air concentration to the emission flux at the center of a square source (g/m^2-s per kg/m^3)	**93.77[a]**
V/fraction of vegetative cover (unitless)	**0.5 (50%)**
U_m/mean annual windspeed (m/s)	**4.69**
U_t/equivalent threshold value of windspeed at 7m (m/s)	**11.32**
F(x)/function dependent on U_m/U_t derived using Cowherd et al. (1985) (unitless)	**0.194**

[a] Assumes a 0.5 acre emission source; for site-specific values, consult Appendix D.

Equation 4-6
Screening Level Equation for Inhalation of Carcinogenic Volatile Contaminants in Soil
- Commercial/Industrial Scenario

$$\text{Screening Level (mg/kg)} = \frac{TR \times AT \times 365 d/yr}{URF \times 1{,}000 \mu g/mg \times EF \times ED \times \frac{1}{VF}}$$

Parameter/Definition (units)	Default
TR/target cancer risk (unitless)	10^{-6}
AT/averaging time (yr)	70
URF/inhalation unit risk factor ($\mu g/m^3)^{-1}$	chemical-specific (Appendix C)
EF/exposure frequency (d/yr) **Outdoor Worker**	**225**
ED/exposure duration (yr) **Outdoor Worker**	**25**
VF/soil-to-air volatilization factor (m^3/kg)	**chemical-specific (Equation 4-8)**

Equation 4-7
Screening Level Equation for Inhalation of Non-carcinogenic Volatile Contaminants in Soil - Commercial/Industrial Scenario

$$\text{Screening Level (mg/kg)} = \frac{THQ \times AT \times 365 d/yr}{EF \times ED \times [\frac{1}{RfC} \times \frac{1}{VF}]}$$

Parameter/Definition (units)	Default
THQ/target hazard quotient (unitless)	1
AT/averaging time (yr) **Outdoor Worker**	**25**[a]
EF/exposure frequency (d/yr) **Outdoor Worker**	**225**
ED/exposure duration (yr) **Outdoor Worker**	**25**
RfC/inhalation reference concentration (mg/m^3)	chemical-specific (Appendix C)
VF/soil-to-air volatilization factor (m^3/kg)	**chemical-specific (Equation 4-8)**

[a] For non-carcinogens, averaging time equals exposure duration.

Equation 4-8
Derivation of the Volatilization Factor
- Commercial/Industrial Scenario

$$VF = \frac{Q/C_{vol} \times (3.14 \times D_A \times T)^{1/2} \times 10^{-4} (m^2/cm^2)}{(2 \times \rho_b \times D_A)}$$

where:

$$D_A = \frac{[(\theta_a^{10/3} D_i H' + \theta_w^{10/3} D_w) / n^2]}{\rho_b K_d + \theta_w + \theta_a H'}$$

Parameter/Definition (units)	Default
VF/volatilization factor (m^3/kg)	chemical-specific
D_A/apparent diffusivity (cm^2/s)	chemical-specific
Q/C_{vol} /inverse of the ratio of the geometric mean air concentration to the volatilization flux at center of a square source (g/m^2-s per kg/m^3)	**68.18[a]**
T/exposure interval (s)	9.5×10^8
ρ_b/dry soil bulk density (g/cm^3)	**1.5**
θ_a/air-filled soil porosity (L_{air}/L_{soil})	$n-\theta_w$
n/total soil porosity (L_{pore}/L_{soil})	$1-(\rho_b/\rho_s)$
θ_w/water-filled soil porosity (L_{water}/L_{soil})	**0.15**
ρ_s/soil particle density (g/cm^3)	2.65
D_i/diffusivity in air (cm^2/s)	chemical-specific[b]
H′/dimensionless Henry's law constant	chemical-specific[b]
D_w/diffusivity in water (cm^2/s)	chemical-specific[b]
K_d/soil-water partition coefficient (cm^3/g)	for organics: $K_d = K_{oc} \times f_{oc}$ for inorganics: see Appendix C[c]
K_{oc}/soil organic carbon partition coefficient (cm^3/g)	chemical-specific[b]
f_{oc}/fraction organic carbon in soil (g/g)	**0.006 (0.6%)**

[a] Assumes a 0.5 acre emission source; for site-specific values, consult Appendix D.
[b] See Appendix C.
[c] Assume a pH of 6.8 when selecting default K_d values for metals.

Calculation of Site Specific Risk Reduction Standards (SSRRSs)
Construction Worker Scenario

Equation 5-1
Screening Level Equation for Combined Subchronic Ingestion and Dermal Absorption Exposure to Carcinogenic Contaminants in Soil
Construction Scenario - Construction Worker

$$\text{Screening Level (mg/kg)} = \frac{TR \times BW \times AT \times 365\,d/yr}{(EF \times ED \times 10^{-6} kg/mg)\,[(SF_o \times IR) + (SF_{ABS} \times AF \times ABS_d \times SA \times EV)]}$$

Parameter/Definition (units)	Default
TR/target cancer risk (unitless)	10^{-6}
BW/body weight (kg)	70
AT/averaging time (years)	70
EF/exposure frequency (days/year)	**site-specific**
ED/exposure duration (years)	**site-specific**
SF_o/oral cancer slope factor $(mg/kg\text{-}d)^{-1}$	chemical-specific (Appendix C)
IR/soil ingestion rate (mg/d)	330
SF_{ABS}/dermally adjusted cancer slope factor $(mg/kg\text{-}d)^{-1}$	chemical-specific (Equation 3-3)
AF/skin-soil adherence factor (mg/cm^2-event)	**0.3**
ABS_d/dermal absorption fraction (unitless)	chemical-specific (Exhibit 3-3 and Appendix C)
SA/skin surface area exposed (cm^2)	**3,300**
EV/event frequency (events/day)	**1**

Equation 5-2
Screening Level Equation for Combined Subchronic Ingestion and Dermal Absorption Exposure to Non-Carcinogenic Contaminants in Soil
Construction Scenario - Construction Worker

$$\text{Screening Level (mg/kg)} = \frac{THQ \times BW \times AT \times 365\,d/yr}{(EF \times ED \times 10^{-6} kg/mg)\left[\left(\frac{1}{HBL_{sc}} \times IR\right) + \left(\frac{1}{HBL_{ABS}} \times AF \times ABS_d \times SA \times EV\right)\right]}$$

Parameter/Definition (units)	Default
THQ/target hazard quotient (unitless)	1
BW/body weight (kg)	70
AT/averaging time (years)	**site specific[a]**
EF/exposure frequency (days/year)	**site specific**
ED/exposure duration (years)	**site specific**
HBL_{sc}/subchronic health-based limit (mg/kg-d)	chemical-specific
IR/soil ingestion rate (mg/d)	330
HBL_{ABS}/dermally-adjusted subchronic health-based limit (mg/kg-d)	chemical-specific (Equation 3-4)
AF/skin-soil adherence factor (mg/cm^2-event)	**0.3**
ABS_d/dermal absorption fraction (unitless)	chemical-specific (Exhibit 3-3 and Appendix C)
SA/skin surface exposed (cm^2)	**3,300**
EV/event frequency (events/day)	**1**

[a] For non-carcinogens, averaging time equals to exposure duration.

Equation 5-3
Screening Level Equation for Subchronic Inhalation of Carcinogenic Fugitive Dusts
Construction Scenario - Construction Worker

$$\text{Screening Level (mg/kg)} = \frac{TR \times AT \times 365d/yr}{URF \times 1{,}000\mu g/mg \times EF \times ED \times \frac{1}{PEF_{sc}}}$$

Parameter/Definition (units)	Default
TR/target cancer risk (unitless)	10^{-6}
AT/averaging time (years)	70
URF/inhalation unit risk factor $(\mu g/m^3)^{-1}$	chemical -specific (Appendix C)
EF/exposure frequency (days/year)	**site-specific**
ED/exposure duration (years)	**site-specific**
PEF_{sc}/subchronic road particulate emission factor (m^3/kg)	**site-specific (Equation 5-5)**

Equation 5-4
Screening Level Equation for Subchronic Inhalation of Non-carcinogenic Fugitive Dusts
Construction Scenario - Construction Worker

$$\text{Screening Level (mg/kg)} = \frac{THQ \times AT \times 365d/yr}{EF \times ED \times \left(\frac{1}{HBL_{sc}} \times \frac{1}{PEF_{sc}}\right)}$$

Parameter/Definition (units)	Default
THQ/target hazard quotient (unitless)	1
AT/averaging time (years)	**site-specific[a]**
EF/exposure frequency (days/year)	**site-specific**
ED/exposure duration (years)	**site-specific**
HBL_{sc}/subchronic health-based limit (mg/m^3)	chemical-specific
PEF_{sc}/subchronic road particulate emission factor (m^3/kg)	**site-specific (Equation 5-5)**

[a] For non-carcinogens, averaging time equals exposure duration.

Equation 5-5
Derivation of the Particulate Emission Factor
Construction Scenario - Construction Worker

$$PEF_{sc} = Q/C_{sr} \times \frac{1}{F_D} \times \left[\frac{T \times A_R}{556 \times (W/3)^{0.4} \times \frac{(365d/yr - p)}{365d/yr} \times \Sigma VKT} \right]$$

Parameter/Definition (units)	Default
PEF_{sc}/subchronic road particulate emission factor (m^3/kg)	**site-specific**
Q/C_{sr}/ inverse of the ratio of the 1-h geometric mean air concentration to the emission flux along a straight road segment bisecting a square site (g/m^2-s per kg/m^3)	**23.02[a] (Equation 5-6)**
F_D/dispersion correction factor (unitless)	0.185 (Appendix E)
T/total time over which construction occurs (s)	**site-specific**
A_R/surface area of contaminated road segment (m^2) **L_R/length of road segment (ft)** **W_R/width of road segment (ft)**	**274.213** **($A_R = L_R \times W_R \times 0.092903 m^2/ft^2$)**
W/mean vehicle weight (tons)	**site-specific**
p/number of days with at least 0.01 inches of precipitation (days/year)	**site-specific (Exhibit 5-2)**
• VKT/sum of fleet vehicle kilometers traveled during the exposure duration (km)	**site-specific**

[a] Assumes a 0.5 acre site

Equation 5-6
Derivation of the Dispersion Factor for Particulate Emissions from Unpaved Roads - Construction Scenario

$$Q/C_{sr} = A \times \exp\left[\frac{(\ln A_s - B)^2}{C}\right]$$

Parameter/Definition (units)	Default
Q/C_{sr}/inverse of the ratio of the 1-h geometric mean air concentration to the emission flux along a straight road segment bisecting a square site (g/m^2-s per kg/m^3)	23.02[a]
A/constant (unitless)	12.9351
A_s/areal extent of site surface soil contamination (acres)	0.5
B/constant (unitless)	5.7383
C/constant (unitless)	71.7711

[a] Assumes a 0.5 acre site