

N00207.AR.003511
NAS JACKSONVILLE
5090.3a

LETTER REGARDING REGULATORY HEALTH BASED CLEANUP GOALS FOR DEFENSE
SITES NAS JACKSONVILLE FL
2/14/1994
FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Environmental Protection

Memorandum

TO: Jorge Caspary, Technical Review Section
Bureau of Waste Cleanup

THROUGH: Jim Crane, Technical Review Section *JJC*
Bureau of Waste Cleanup ~~422222~~

FROM: Ligia Mora-Applegate, Technical Review Section
Bureau of Waste Cleanup

DATE: February 14, 1994

SUBJECT: *Health-based Cleanup Goals for the DOD Sites*

Attached, for your information and use, please find the soil cleanup goals. If there is ground water contamination, the leachability-based cleanup goals should be considered and compared with the health-based cleanup goals using the applicable scenario (i.e., residential or industrial). The lowest of the two sets should be the final cleanup goal; if the industrial scenario is applicable, the site must have a deed restriction for residential land uses and the like.

Among the health-based levels, if a residential scenario is applicable you need to look under the column designated *aggregate resident* for carcinogens and *child resident* for non-carcinogens and choose the **lowest** of the two sets. If an industrial scenario is applicable, look under the columns designated *general worker*, and choose the **lowest** of the two sets.

If any of the levels are below background or the Method Detection Limit (MDL) any of the latter two will suffice.

If you have any questions, please see me.

- CC: V-TRAINOR
- P. GEORGARION
- F. BRADON
- W. BRITTON
- G. BEUMEL
- A. OLIS
- P. LAYNE
- G. BROWN
- S/E

Summary of Soil Target Levels

Chemical Name	Soil Target Level (mg/kg) Based on an Excess Cancer Risk of 1E-06			Soil Target Level (mg/kg) Based on a Hazard Index of 1			Soil Target Levels (mg/kg)
	Aggregate Resident	Child Resident	General Worker	Aggregate Resident	Child Resident	General Worker	Based on Leachability
VOCs							
Acetone	ND	ND	ND	7.35E+03	2.70E+03	1.25E+04	6.87E-02
Benzene	2.82E+00	1.02E+01	4.92E+00	ND	ND	ND	2.60E-04
Bromodichloromethane	3.61E+00	6.18E+00	7.57E+00	1.92E+03	6.57E+02	3.35E+03	3.57E-04
2-Butanone	ND	ND	ND	3.30E+04	2.05E+04	4.91E+04	3.60E-02
Ethylbenzene	ND	ND	ND	2.34E+04	6.53E+03	4.43E+04	6.88E-02
Methylene chloride	2.30E+01	6.34E+01	4.22E+01	1.06E+04	3.59E+03	1.85E+04	5.57E-04
Perchloroethylene	1.53E+01	1.61E+01	4.14E+01	3.40E+02	1.44E+02	5.57E+02	2.47E-03
Trichloroethylene	1.34E+01	3.95E+01	2.42E+01	ND	ND	ND	1.04E-03
Xylene (total)	ND	ND	ND	9.43E+04	3.79E+04	1.56E+05	1.15E-02
BNAs							
Acenaphthene	ND	ND	ND	2.02E+04	4.00E+03	4.64E+04	1.86E-01
Acenaphthylene	ND	ND	ND	8.90E+03	2.63E+03	1.63E+04	5.09E-02
Anthracene	ND	ND	ND	8.20E+04	1.83E+04	1.73E+05	5.90E+01
Benzo(a)anthracene	1.51E+00	1.21E+00	5.04E+00	ND	ND	ND	2.76E+01
Benzo(b)fluoranthene	1.50E+00	1.21E+00	5.01E+00	ND	ND	ND	1.10E+01
Benzo(k)fluoranthene	1.50E+00	1.21E+00	4.97E+00	ND	ND	ND	1.10E+01
Benzo(a)pyrene	1.51E-01	1.21E-01	5.04E-01	ND	ND	ND	2.20E+00
Benzo(g,h,i)perylene	ND	ND	ND	1.41E+04	2.26E+03	3.94E+04	3.20E+01
Butylbenzylphthalate	ND	ND	ND	9.35E+04	1.50E+04	2.78E+05	1.11E+00
Carbazole	5.87E+01	4.48E+01	2.24E+02	ND	ND	ND	ND
Chrysene	1.50E+01	1.21E+01	5.03E+01	ND	ND	ND	4.00E+00
Dibenzo(a,h)anthracene	1.51E-01	1.21E-01	5.05E-01	ND	ND	ND	6.60E+01
Dibenzofuran	ND	ND	ND	2.01E+03	3.07E+02	6.40E+03	ND
Fluoranthene	ND	ND	ND	1.82E+04	2.99E+03	4.96E+04	2.13E+01
Fluorene	ND	ND	ND	1.49E+04	2.78E+03	3.60E+04	4.11E+00
n-Hexane	ND	ND	ND	3.02E+04	4.61E+03	9.60E+04	ND
Indeno(1,2,3-c,d)pyrene	1.51E+00	1.21E+00	5.04E+00	ND	ND	ND	3.20E+01
2-Methylnaphthalene	ND	ND	ND	9.00E+02	1.90E+02	2.03E+03	ND
Naphthalene	ND	ND	ND	9.60E+03	2.28E+03	2.00E+04	1.33E-02
Pentachlorophenol	9.68E+00	7.44E+00	3.66E+01	1.49E+04	2.30E+03	4.71E+04	1.06E-01
Phenanthrene	ND	ND	ND	1.47E+04	2.76E+03	3.50E+04	2.81E-01
Pyrene	ND	ND	ND	1.29E+04	2.19E+03	3.38E+04	1.60E+01
Pesticides/Others							
4,4'-DDD	4.78E+00	3.71E+00	1.75E+01	ND	ND	ND	1.54E-01
4,4'-DDE	3.37E+00	2.62E+00	1.24E+01	ND	ND	ND	8.80E-01
DDT	3.23E+00	2.60E+00	1.13E+01	2.31E+02	3.74E+01	6.67E+02	4.86E-02
Chlordane, alpha-	8.80E-01	6.85E-01	3.21E+00	2.93E+01	4.57E+00	8.89E+01	5.60E-01
Chlordane, gamma-	8.80E-01	6.85E-01	3.21E+00	2.93E+01	4.57E+00	8.89E+01	5.60E-01
Dieldrin	7.20E-02	5.59E-02	2.69E-01	2.46E+01	3.82E+00	7.68E+01	3.49E-04
Endrin	ND	ND	ND	1.48E+02	2.29E+01	4.62E+02	6.98E-03
Freon	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	4.85E-02	7.79E-02	1.01E-01	1.19E+00	4.13E-01	2.04E+00	1.07E-04
Toxaphene	4.04E-02	1.67E-01	6.93E-02	ND	ND	ND	6.07E-03
Metals							
Aluminum	ND	ND	ND	ND	ND	ND	ND
Arsenic	7.11E-01	5.20E-01	3.16E+00	1.60E+02	2.34E+01	5.95E+02	ND
Cadmium	6.35E+02	3.18E+03	1.07E+03	2.30E+02	3.75E+01	6.21E+02	ND
Chromium (hexavalent)	9.53E+01	4.77E+02	1.60E+02	1.99E+03	3.59E+02	4.34E+03	ND
Chromium (trivalent)	ND	ND	ND	2.16E+05	5.66E+04	3.06E+05	ND
Cobalt	ND	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	1.96E+04	2.88E+03	7.16E+04	ND
Iron	ND	ND	ND	ND	ND	ND	ND
Lead	ND	ND	ND	ND	ND	ND	ND
Manganese	ND	ND	ND	2.15E+03	3.68E+02	5.22E+03	ND
Nickel	1.16E+00	1.01E+00	3.24E+00	8.29E+03	1.45E+03	1.91E+04	ND
Vanadium	ND	ND	ND	2.74E+03	5.00E+02	5.91E+03	ND
Zinc	ND	ND	ND	1.57E+05	2.33E+04	5.51E+05	ND

SOIL CLEAN-UP LEVEL CALCULATIONS & ASSUMPTIONS

Using Inhalation Slope Factor, Cs =

$$\frac{\text{Risk} * \text{BW} * \text{AT}}{\text{EF} * \text{ED} * \text{FI} * ((\text{SFo} * \text{IR} * 1\text{E-}06 \text{ kg/mg}) + (\text{SFd} * \text{SA} * \text{AF} * \text{ABS} * 1\text{E-}06 \text{ kg/mg}) + (\text{SFi} * \text{InhR} * (1/\text{VF} + 1/\text{PEF})))}$$

Using Inhalation Unit Risk, Cs =

$$\frac{\text{Risk} * \text{BW} * \text{AT}}{\text{EF} * \text{ED} * \text{FI} * ((\text{SFo} * \text{IR} * 1\text{E-}06 \text{ kg/mg}) + (\text{SFd} * \text{SA} * \text{AF} * \text{ABS} * 1\text{E-}06 \text{ kg/mg}) + (\text{IUR} * \text{BW} * 1000 \mu\text{g/mg} * (1/\text{VF} + 1/\text{PEF})))}$$

Using Inhalation Reference Dose, Cs =

$$\frac{\text{Hazard} * \text{BW} * \text{AT}}{\text{EF} * \text{ED} * \text{FI} * (((1/\text{RfDo}) * \text{IR} * 1\text{E-}06 \text{ kg/mg}) + ((1/\text{RfDd}) * \text{SA} * \text{AF} * \text{ABS} * 1\text{E-}06 \text{ kg/mg}) + ((1/\text{RfDi}) * \text{InhR} * (1/\text{VF} + 1/\text{PEF})))}$$

Using Inhalation Reference Concentration, Cs =

$$\frac{\text{Hazard} * \text{BW} * \text{AT}}{\text{EF} * \text{ED} * \text{FI} * (((1/\text{RfCo}) * \text{IR} * 1\text{E-}06 \text{ kg/mg}) + ((1/\text{RfCd}) * \text{SA} * \text{AF} * \text{ABS} * 1\text{E-}06 \text{ kg/mg}) + ((1/\text{RfCi}) * \text{BW} * (1/\text{VF} + 1/\text{PEF})))}$$

ASSUMPTIONS

Dermal Contact with Chemicals in Soil (Average)

Assumption	Value	Code	Reference
Chemical Concentration (ppm)	chemical specific	CS	
Surface Area - worker (cm ² /day)	2300	SAw	FDEP Default
Surface Area - aggregate resident (cm ² /day)	4280	SAA	FDEP Default
Surface Area - child resident (cm ² /day)	1800	SAC	FDEP Default
Conversion Factor (kg/mg)	1.00E-06	CFkg/mg	
Conversion Factor (μg/mg)	1.00E+03	CFμg/mg	
Soil to Skin Adherence Factor-resident (mg/cm ²)	0.2	AFr	FDEP Default
Soil to Skin Adherence Factor-worker (mg/cm ²)	0.6	AFw	FDEP Default
Absorption Factor - organic (unitless)	0.01	ABSo	FDEP Default
Absorption Factor - inorganic (unitless)	0.001	ABSin	FDEP Default
Soil Ingestion Rate - worker (mg/day)	50	IRw	FDEP Default
Soil Ingestion Rate - aggregate resident (mg/day)	120	IRa	FDEP Default
Soil Ingestion Rate - child resident (mg/day)	200	IRc	FDEP Default
Fraction Ingested (unitless)	1	FI	FDEP Default
Inhalation Rate - worker (m ³ /day)	20	InhRw	FDEP Default
Inhalation Rate - aggregate resident (m ³ /day)	20	InhRa	FDEP Default
Inhalation Rate - child resident (m ³ /day)	10	InhRc	
Exposure Frequency - worker (day/yr)	250	EFw	FDEP Default
Exposure Frequency - residents	350	EFr	FDEP Default
Exposure Duration - worker (yr)	25	EDw	FDEP Default
Exposure Duration - aggregate resident (yr)	30	EDa	FDEP Default
Exposure Duration - child resident (yr)	6	EDc	FDEP Default
Body Weight - worker (kg)	70	BWw	FDEP Default
Body Weight - aggregate resident (kg)	62	BWa	FDEP Default
Body Weight - child resident (kg)	15	BWc	FDEP Default
Averaging Time - worker, NC (days)	9125	ATwnc	FDEP Default
Averaging Time - aggregate resident (NC) (days)	10950	ATanc	FDEP Default
Averaging Time - child resident (NC) (days)	2190	ATenc	FDEP Default
Averaging Time - Cancer (days)	25550	ATc	FDEP Default

SOIL CLEAN-UP LEVEL CALCULATIONS & ASSUMPTIONS

VOLATILIZATION MODEL*

Soil-to-air Volatilization Factor (VF)

Assumption	Exposure	Abbr
Inverse Mean Conc. at Center (g/m ² -s per kg/m ³)	101.8	Q-C95%UCL
Conversion Factor (m ² /cm ²)	0.0001	CFm ² /cm ²
Diffusivity in air (cm ² /sec)	chemical specific	Di
Soil moisture content (cm ³ water/gm soil)	10%	theta
Soil bulk density (gm/cm ³)	1.5	beta
True soil density or particle density (gm/cm ³)	2.65	rho
Total soil porosity (unitless)	0.434	Pt
Air filled soil porosity (unitless)	0.284	Pa
Effective diffusivity (cm ² /sec)	chemical specific	Dei
Organic carbon partition coefficient (cm ³ /g)	chemical specific	Koc
Organic carbon content of soil (fraction)	2%	OC
Soil-water partition coefficient (cm ³ /g)	chemical specific	Kd
Soil-air partition coeff. (g soil/cm ³ air)	chemical specific	Kas
Exposure interval (seconds)	7.90E+08	T
alpha (cm ² /sec)	chemical specific	alpha
Soil-to-air Volatilization Factor (m ³ /kg)	chemical specific	VF

$$\begin{aligned}
 \text{Dei (cm}^2/\text{sec)} &= \text{Di} * [\text{Pa}^{(10/3)}/\text{Pt}^2] \\
 \text{Pa (unitless)} &= \text{Pt} - (\text{theta} * \text{beta}) \\
 \text{Pt (unitless)} &= 1 - (\text{beta}/\text{rho}) \\
 \text{Kas (g soil/cm}^3 \text{ air)} &= \text{Hprime}/\text{Kd} \\
 \text{Kd (cm}^3/\text{kg)} &= \text{Koc} * \text{OC} \\
 \text{alpha (cm}^2/\text{sec)} &= (\text{Dei} * \text{Pa}) / [\text{Pa} + (\text{rho} * ((1 - \text{Pa}) / \text{Kas}))] \\
 \text{VF (m}^3/\text{kg)} &= \frac{\text{Q-C95\%UCL} * \text{CFm}^2/\text{cm}^2 * (3.14 * \text{alpha} * \text{T})^{0.5}}{(2 * \text{Dei} * \text{Pa} * \text{Kas})}
 \end{aligned}$$

Soil Saturation Concentration (C_{sat})

UL of soil free moisture (mg/L water)	chemical specific	Cw
Soil Moisture content (kg water/kg soil)	10%	Thetam
Water Solubility (mg/L water)	chemical specific	Schem
Water filled soil porosity (unitless)	0.15	Pw
Henry's Law Constant (atm-m ³ /mol)	chemical specific	Hchem
Henry's Constant Unitless (unitless)	chemical specific	Hprime
Soil Saturation Concentration (mg/kg)	chemical specific	Csat

$$\begin{aligned}
 \text{Cw (mg/L water)} &= \text{Schem} * \text{Thetam} \\
 \text{Pw (unitless)} &= \text{Pt} - \text{Pa} \\
 \text{Hprime (unitless)} &= \text{Hchem} * 41 \\
 \text{Csat (mg/kg)} &= \frac{[(\text{Kd} * \text{Cw} * \text{beta}) + (\text{Cw} * \text{Pw}) + (\text{Cw} * \text{Hprime} * \text{Pa})]}{\text{beta}}
 \end{aligned}$$

Particulate Emission Factor (PEF)

Respirable fraction (g/m ² -hr)	0.036	Rf2
Frac. vegetative cover (unitless)	0	Gchem
Mean annual wind speed (m/sec)	4.5	Um
Equiv. threshold value of wind speed at 10m (m/sec)	12.8	Ut
Func. dep. on Um/Ut (unitless)	0.0497	F(x)
Particulate Emission Factor (m ³ /kg)	chemical specific	PEF

$$\text{PEF (m}^3/\text{kg)} = \frac{\text{Q-C95\%UCL} * 3600 \text{ sec/hr}}{[\text{Rf} * (1 - \text{Gchem}) * (\text{Um}/\text{Ut})^3 * \text{F}(x)]}$$

Soil Screening Level Partitioning Equation for Migration to Groundwater

Cw - acceptable concentration in water (mg/l)	chemical specific	ACW
Koc - organic carbon partitioning coefficient (L/kg)	chemical specific	Koc
Foc - fraction of organic carbon in soil (unitless)	2.00E-03	Foc
theta - soil porosity (Lporosity/Lsoil)	5.00E-01	theta2
S - fraction water content (Lwater/Lporo)	3.00E-01	S
SD - soil bulk density (kg/Lsoil)	1.60E+00	SD

$$\text{Screening Level in Soil (mg/kg)} = \text{ACW} * [(\text{Koc} * \text{Foc}) + (\text{theta}2 * (\text{S}/\text{SD}))]$$

DRAFT

Leachability-based Acceptable Soil Concentrations

$$C_s = C_w(K_{oc} * f_{oc} + \theta * S/BD)$$

C_s = Acceptable soil concentration (mg/kg)

C_w = Groundwater standard or criteria (mg/L)

f_{oc} = Organic carbon fraction = 0.002

K_{oc} = Organic carbon partitioning coefficient, chemical-specific value (L/kg)

θ = Soil porosity (L_{pore}/L_{soil}) = 0.5

S = Fraction water content (L_{water}/L_{pore}) = 0.3

BD = Bulk density (Kg/L_{soil}) = 1.5

Site measured values of organic carbon, soil porosity, fraction of water content and soil bulk density can be substituted into the partitioning equation to calculate levels more tailored to site characteristics.

For inorganic constituents K_d should be calculated and used in the above equation in place of the $K_{oc} * f_{oc}$ parameters.

TCLP (where appropriate) should also be run.

DRAFT

January 5, 1994

Ligia Mora-Applegate
Bureau of Waste Cleanup
Florida Department of Environmental Regulation
Room 471A, Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Dear Ms. Mora-Applegate:

I am writing as a follow-up to our conference call with individuals in the U.S. Environmental Protection Agency on November 15, 1993. As you recall, this conference call included Jeanine Dinan at EPA in Washington, D.C. and Elmer Akin of Region IV in Atlanta. One of the topics of this call was the current default value for the PEF (particulate emission factor) used in the EPA's proposed Soil Screening Level Guidance. This value, $4.7 \times 10^9 \text{ m}^3/\text{kg}$, corresponds to a respirable dust concentration from the contaminated source of about $0.2 \mu\text{g}/\text{m}^3$. The most recent information I have indicates that the measured, ambient PM_{10} concentrations for most locations in Florida are about $20 \mu\text{g}/\text{m}^3$, on average. Accordingly, the default PEF factor essentially assumes that 1% of the respirable dust at a site is from site soils.

I was curious to know what data exist to support this default PEF value as representing a reasonable and conservative number to use in risk assessments of contaminated soil. My impression from the response I received is that there is very little. There was general agreement that this value would be applicable only for undisturbed soil; vehicular traffic over uncovered contaminated soil would generate much higher dust concentrations. Confidence in its appropriateness at undisturbed sites seems less than complete, however, based upon comments made during the conference call. There are apparently EPA-sponsored studies under way that should be helpful in the evaluation of the suitability of this default value, and it is my impression that the results of these studies should be available soon. In the interim, it might be prudent to use a somewhat more conservative PEF value of $4.7 \times 10^8 \text{ m}^3/\text{kg}$, which would correspond roughly to an assumption that 10% of respirable dust at a site originates from site soils.

I will let you know as soon as I receive any updated information regarding the EPA studies, or any others, dealing with particulate emissions from contaminated sites.

Regards,

Stephen M. Roberts, Ph.D.

~~ASAP~~ ~~Robert Clanton~~

DRAFT

ATTACHMENT III CALCULATION OF ACCEPTABLE SOIL CONCENTRATIONS

The equations to be used to develop Acceptable Soil Levels based on carcinogenic and non-carcinogenic effects are listed on the following page. Each of these equations includes input from ingestion, dermal contact, and inhalation. Selection of the appropriate equation to use is based, in part, on the toxicity criteria information available for the inhalation route. If, for a given chemical, inhalation toxicity criteria are available in air concentration form (i.e., in the form of a reference concentration (RfC) for non-cancer effects, or inhalation unit risk factor (URF) for carcinogenic effects), the equations that include these as variables in the inhalation component should be used. If inhalation toxicity criteria in concentration form are not available, then values in the form of inhalation reference doses (RfD) or inhalation slope factors should be used, as appropriate. A set of equations with an inhalation RfD or slope factor as a variable in the inhalation component has been provided. If no inhalation toxicity criteria are available for a chemical, an inhalation RfD and slope factor (if applicable) should be developed. Most often, this is done using toxicity criteria developed for ingestion and route-to-route extrapolation. Route-to-route extrapolation is relevant only for systemic toxicity (as opposed to, for example, pulmonary irritant effects) and must take into consideration the inhalation bioavailability and usually the oral bioavailability. It is recommended that route-to-route extrapolations to derive inhalation toxicity criteria should be performed or reviewed by a toxicologist.

The ingestion component of the Acceptable Soil Level equations does not include a bioavailability term. This is because the vast majority of toxicity criteria available for the ingestion route are based upon administered, rather than absorbed, dose. For those few chemicals with ingestion toxicity criteria based upon absorbed dose, a bioavailability variable should be incorporated into the ingestion component of the equation. The source of the oral bioavailability factor used in calculating an Acceptable Soil Level in these circumstances should be documented.

Each of the equations includes a dermal toxicity value (dermal RfD or dermal slope factor). Dermal toxicity values are not provided by the USEPA, and must usually be derived by route-to-route extrapolation from ingestion toxicity criteria. This type of extrapolation is only valid, however, when the toxicity produced by dermal absorption is systemic rather than localized. The dermal component of the equations listed above includes a bioavailability variable and therefore calculates an absorbed dose. Accordingly, the dermal RfD or slope factor must also be based upon absorbed dose. As discussed above, most ingestion toxicity criteria that would be used to obtain a dermal RfD or slope factor are based on an administered dose. To convert an administered-dose ingestion RfD to an absorbed-dose value, it must be multiplied by the oral bioavailability; an administered-dose slope factor is converted by dividing by the oral bioavailability. In developing dermal RfDs or slope factors, the approach used for each chemical should be clearly documented, and if applicable, the selection of the oral bioavailability factor should be justified.

There are some chemicals which produce route-dependent toxicity. For example, cadmium is currently considered a carcinogen, but only by the inhalation route. In such cases, the Acceptable Soil Level equation should be modified to include input from only the relevant route(s).

Carcinogenic chemicals also possess the ability to produce non-cancer health effects. Consequently, Acceptable Soil Levels for carcinogens should be calculated based upon both cancer and non-cancer health effects. In general, the applicable Acceptable Soil Level will be the lesser of the two values.

Acceptable Soil Levels for Carcinogens

using the inhalation slope factor:

$$C_s = \frac{TR \times BW \times AT}{EF \times ED \times FC \times \left[(SF_o \times IR_o \times 10^{-6} \text{ kg/mg}) + (SF_d \times SA \times AF \times DA \times 10^{-6} \text{ kg/mg}) + \left(SF_i \times IR_i \times \left(\frac{1}{VF} + \frac{1}{PEF} \right) \right) \right]}$$

using the inhalation unit risk factor:

$$C_s = \frac{TR \times BW \times AT}{EF \times ED \times FC \times \left[(SF_o \times IR_o \times 10^{-6} \text{ kg/mg}) + (SF_d \times SA \times AF \times DA \times 10^{-6} \text{ kg/mg}) + \left(URF \times BW \times 1000 \mu\text{g/mg} \times \left(\frac{1}{VF} + \frac{1}{PEF} \right) \right) \right]}$$

Acceptable Soil Levels for Non-Carcinogens

using the inhalation reference dose:

$$C_s = \frac{THI \times BW \times AT}{EF \times ED \times FC \times \left[\left(\frac{1}{RfD_o} \times IR_o \times 10^{-6} \text{ kg/mg} \right) + \left(\frac{1}{RfD_d} \times SA \times AF \times DA \times 10^{-6} \text{ kg/mg} \right) + \left(\frac{1}{RfD_i} \times IR_i \times \left(\frac{1}{VF} + \frac{1}{PEF} \right) \right) \right]}$$

using the inhalation reference concentration:

$$C_s = \frac{THI \times BW \times AT}{EF \times ED \times FC \times \left[\left(\frac{1}{RfC} \times IR_o \times 10^{-6} \text{ kg/mg} \right) + \left(\frac{1}{RfC} \times SA \times AF \times DA \times 10^{-6} \text{ kg/mg} \right) + \left(\frac{1}{RfC} \times BW \times \left(\frac{1}{VF} + \frac{1}{PEF} \right) \right) \right]}$$

C_s = Acceptable Soil Concentration
 TR = Target Risk (unitless)
 THI = Target Hazard Index (unitless)
 BW = body weight (kg)
 AT = averaging time (days)
 ED = exposure duration (years)
 EF = exposure frequency (days/yr)
 FC = fraction from contaminated source (unitless)

IR_o = ingestion rate, oral (mg/day)
 SA = surface area of skin exposed (cm²)
 AF = adherence factor (mg/cm²/day)
 DA = dermal absorption (unitless)
 IR_i = inhalation rate (m³/day)
 VF = volatilization factor (m³/kg)
 PEF = particulate emission factor (m³/kg)

SF = slope factor, (mg/kg/day)⁻¹
 SF_o = oral
 SF_d = dermal
 SF_i = inhalation
 RfD = reference dose, (mg/kg/day)
 RfD_o = oral
 RfD_d = dermal
 RfD_i = inhalation
 RfC = reference concentration (mg/m³)
 URF = unit risk factor for inhalation (μg/m³)⁻¹

Default Assumptions for Equation Variables

Scenario-Dependent Variables

Variable	Child Resident (age 1-6 years)	Aggregate Resident (age 1 - 30 yrs)	On-Site Worker
BW (body weight)	15 kg	62 kg	70 kg
IRo (ingestion rate, oral)	200 mg/kg	120 mg/day	50 mg/day
FC (fraction from contam. source)	1.0 (100%)	1.0 (100%)	1.0 (100%)
EF (exposure frequency)	350 days/yr	350 days/yr	250 days/yr
ED (exposure duration)	6 yrs	30 yrs	25 yrs
SA (surface area of skin exposed)	1,800 cm ² /day	4,280 cm ² /day	2,300 cm ² /day
AF (adherence factor)	0.2 mg/cm ²	0.2 mg/cm ²	0.6 mg/cm ²
AT (averaging time)			
• non-carcinogens	2,100 days	10,500	6,250 days
• carcinogens	25,550 days	25,550 days	25,550 days

Scenario-Independent Variables

Variable	
TR (target risk)	1 x 10 ⁻⁶
THI (target hazard index)	1.0
DA (dermal absorption)	0.01 for organics; 0.001 for inorganics
IRi (inhalation rate)	20 m ³ /day
PEF (particulate emission factor)	consult DEP for guidance
VF (volatilization factor)	compound specific
SF (slope factor)	compound and route specific
URF (unit risk factor)	compound specific
RfD (reference dose)	compound and route specific
RfC (reference concentration)	compound specific