

**USER'S GUIDE AND BACKGROUND TECHNICAL DOCUMENT FOR
NEVADA DIVISION OF ENVIRONMENTAL PROTECTION
BASIC COMPARISON LEVELS (BCLs) FOR HUMAN HEALTH
FOR THE BMI COMPLEX AND COMMON AREAS**

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DISCLAIMER

The Nevada Division of Environmental Protection (NDEP) Basic Comparison Levels (BCLs) address common human health exposure pathways. They consider neither all potential human health exposure pathways nor do they address ecological concerns. The comparison of site characterization data against these risk-based media concentrations provides for an initial screening evaluation to assist users in risk assessment components such as the evaluation of data usability, determination of extent of contamination, identification of chemicals of potential concern, and identification of preliminary remediation goals. The values are derived using equations from U.S. Environmental Protection Agency (USEPA) guidance, USEPA toxicity criteria, and USEPA exposure factors. NDEP officials may decide to follow the guidance provided herein or act at variance with the guidance, based on analysis of site-specific circumstances or availability of new or more relevant data or regulatory policies. NDEP also reserves the right to change this guidance at any time without public notice. Every effort has been made to ensure accuracy in these tables; however, if an error is found, please send an e-mail to brakvica@ndep.nv.gov.

These BCLs are designed for use at the BMI Complex and Common Areas in Henderson, Nevada. The applicability of the BCLs should be verified prior to use at any other site.

The guidance set out in this document is not final NDEP action. It is neither intended to nor can it be relied upon, to create any rights enforceable by a party in litigation with the state of Nevada.

1.0 BACKGROUND ON NDEP BASIC COMPARISON LEVELS (BCLs)

The Internet version of the Nevada Division of Environmental Protection (NDEP) Basic Comparison Levels (BCLs) can be found at the worldwide web address <http://ndep.nv.gov/bmi/technical.htm>.

Users are advised to employ these BCLs only after fully understanding this guidance. The BCL Table was not generated to represent action levels or final cleanup levels but rather as a technical screening tool to assist users in risk assessment components such as the evaluation of data usability, determination of extent of contamination, identifying chemicals of potential concern, and identifying preliminary remediation goals. The BCL Table contains current human health toxicity values that are combined with standard exposure factors to estimate contaminant concentrations in environmental media (air, soil, and water) that are considered by NDEP to be protective of human exposures (including sensitive sub-groups) over a lifetime. Chemical concentrations above the relevant BCLs do not automatically designate the site as needing a response action. However, exceeding an BCL may suggest that further evaluation of the potential risks posed by site contaminants is appropriate. Further evaluation might include additional sampling, consideration of ambient levels in the environment, or a reassessment of assumptions contained in these screening-level estimates (e.g., appropriateness of route-to-route extrapolations, of using chronic toxicity values to evaluate sub-chronic exposures, refining exposure factors, and/or fate and transport modeling).

For each chemical, BCLs are back-calculated from target risk levels. For the inhalation and direct contact pathways, target risk levels for soil exposures are set at a cumulative one-in-a-million (1×10^{-6}) incremental lifetime cancer risk for the cancer endpoint and a hazard quotient (HQ) of one (1) for the non-cancer endpoint. BCLs for the migration-to-groundwater pathway are back-calculated from the following groundwater concentration limits (in order of preference): non-zero maximum contaminant level goals (MCLGs), maximum contaminant levels (MCLs), or health-based limits (based on a cancer risk of 1×10^{-6} or an HQ of 1), with the exception of lead (see Section 3.6.3) and the residential water BCL for perchlorate. The residential water BCL for perchlorate is the provisional Nevada action level of 18 ppb.

BCLs are intended to provide health protection without knowledge of the specific exposure conditions at the site under study. BCLs are applicable when the exposure factors based on site-specific considerations are likely to be more conservative than the default exposure assumptions used in the BCL Table. BCLs are media contaminant concentrations below which no further action or study at a site is generally warranted, provided that specified application conditions associated with the BCLs are met. In general, if adequate site data collection shows that the measured maximum or 95% upper confidence level (UCL) (where appropriate) concentration of a particular contaminant is below the relevant BCL (see Section 3.6.1 for addressing multiple chemicals), then decisions regarding data usability, extent of contamination, chemicals of potential concern, and/or the need for remediation may be supported. If the maximum or the 95% UCL concentration for relevant media is at or above the BCL, further study, though not necessarily a cleanup action, is warranted. When considering BCLs as initial cleanup goals, it is recommended

that the residential BCL be used, unless agreement has been reached with NDEP officials that a non-residential land use assumption can be justified.

The responsibility for using the BCL Table, and for determining its relevance to site-specific circumstances, lies with the person recommending the values to be used and the user of the table. Before using the BCLs at a particular site, the user should consider whether the exposure pathways and exposure scenarios at the site are fully accounted for in the BCL calculations. NDEP BCLs are based on direct contact pathways (i.e., ingestion, dermal contact, and inhalation) for which generally accepted methods, models, and assumptions have been developed for specific land uses and do not consider impact to ecological receptors [see Conceptual Site Model (CSM) section below]. The BCL table contains guidance on soil chemical impacts to groundwater by identifying chemical-specific dilution-attenuation factors (DAF), which can be multiplied by relevant soil concentrations to obtain a leaching-based BCL (LBCL) for comparison to water standards.

The BCLs will be updated over time, as appropriate (once a year at a minimum), to reflect evolving USEPA guidance, changes in toxicological data, and derivation of toxicological surrogates (as applicable) for BMI Complex and Common Areas compounds of interest. There are a number of exotic chemicals associated with the BMI Complex and Common Areas and the need for surrogate derivation will be completed on a case-by-case basis. Interim changes and special considerations identified by NDEP and users will be posted in Appendix A of the User's Guide, and will be integrated into the BCL Table as needed. Therefore, users are urged to check this appendix for any changes relevant to their site-specific/media-specific chemicals.

1.1 Conceptual Site Model

Developing a CSM is a critical step in properly implementing the soil screening process at a site. The CSM is a comprehensive representation of the site that documents current site conditions. It characterizes the distribution of contaminant concentrations across the site in three dimensions and identifies all potential exposure pathways, migration routes, and potential receptors. The CSM is initially developed from existing site data. Where relevant, these site data should include input from community members about their site knowledge, concerns, and interests, and should be revised continually as new site investigations produce updated or more accurate information. The final CSM represents links among contaminant sources, release mechanisms, exposure pathways, and routes and receptors based on historical information. It summarizes the understanding of the contamination problem.

As an initial check, the CSM should answer the following questions:

- Are there potential ecological concerns?
- Is there potential for land use other than those covered by the screening levels (i.e., residential and commercial/industrial)?
- Are there other likely human exposure pathways that were not considered in development of the BCLs (e.g., impacts on areas used for gardens, farming, fishing, or raising beef, dairy, or other livestock)?
- Are there unusual site conditions (e.g., large areas of contamination, high fugitive dust levels, or wetland or floodplain issues)?

- Is there a probable source of vapor emissions from volatile soil or groundwater contaminants that may affect indoor air?
- Is there potential for a short-term construction scenario to result in higher risks than those associated with the long-term scenarios assumed for the BCLs?

If the answer to any of the questions is yes, then the BCLs may not be applicable to a site.

1.2 Application of the Comparison Levels Table

The decision to use the screening levels at a site will be driven by the potential benefits of having generic risk-based concentrations in the absence of site-specific risk assessments. Potential benefits are as follows:

- Supporting quality assurance programs and data usability evaluations; Limiting the number of chemicals of potential concern (COPCs) evaluated in risk assessments;
- Screening sites to determine the need for further evaluation;
- Prioritizing multiple “hot spots” within a facility or exposure realm; and
- Focusing future risk assessment efforts.

In general, screening-level concentrations provided in the Table are risk-based. However, for soil there are two important exceptions: (1) for several volatile chemicals, screening levels are based on the soil saturation equation (“sat”), and (2) for relatively less toxic inorganic and semi-volatile contaminants, a non-risk-based “ceiling limit” concentration is given as 10^{+5} mg/kg (“max”). The pathways addressed by the BCLs and those not addressed are summarized below.

Environmental Media	Pathways Addressed by BCLs		Pathways not Addressed by BCLs	
		Industrial/ Commercial		Industrial/ Commercial
	Residential		Residential	
Soil	<ul style="list-style-type: none"> • Ingestion • Inhalation of Particulates • Inhalation of VOCs • Dermal Contact 	<ul style="list-style-type: none"> • Ingestion • Inhalation of Particulates • Inhalation of VOCs • Dermal Contact 	<ul style="list-style-type: none"> • Intrusion of VOCs into Indoor Air • Groundwater contact from soil-leached chemicals • Ingestion of Livestock or Produce 	<ul style="list-style-type: none"> • Intrusion of VOCs into Indoor Air • Groundwater contact from soil-leached chemicals • Particulate Emission During Construction/Excavations Activities
Groundwater	<ul style="list-style-type: none"> • Ingestion from Drinking • Inhalation of VOCs 	<ul style="list-style-type: none"> • None 	<ul style="list-style-type: none"> • Dermal Absorption while Bathing • Intrusion of VOCs into Indoor Air 	<ul style="list-style-type: none"> • Ingestion from Drinking • Inhalation of VOCs • Dermal Absorption • Intrusion of VOCs into Indoor Air

VOC – volatile organic compound

1.3 Potential Issues and Misapplication of BCLs

As discussed previously, the BCLs should be used only when the conditions at the site being screened are similar to those under which the BCLs were derived for use. Special care should be exercised to prevent misuse of the BCLs and to protect human health. Specifically, the following should be avoided:

- Applying screening levels to a site without adequately developing a conceptual site model that identifies relevant exposure pathways and exposure scenarios.
- Not considering background concentrations when choosing screening levels.
- Use of screening levels as cleanup levels without considering other relevant criteria.
- Use of screening levels as cleanup levels without verifying applicability with a qualified risk assessment toxicologist.
- Use of outdated screening-level tables that have been superseded by more recent publications.
- Not considering the effects of the presence of multiple chemicals.

2.0 NDEP BASIC COMPARISON LEVELS (BCLs)

The BCL Table was generated using equations incorporated into a calculation spreadsheet, except for the column “DAF” [the dilution-attenuation factor for use in calculating leaching-based BCLs]. Toxicity values, as well as physical and chemical parameters, are input into the spreadsheet. There are seven primary sections of the spreadsheet: 1) toxicity values, 2) physical/chemical input parameters, 3) BCLs for exposure-specific/scenario-specific risks and hazards for residential land use scenarios, 4) BCLs for industrial/commercial land use scenarios, 5) BCLs for ambient air, 6) BCLs for residential water, and 7) the final integrated BCLs. The “printable” version of the BCL Table contains only the toxicity values, volatile organic compound (VOC) designation, skin absorption value, and final comparison levels. The default values and equations used in developing the table are discussed below.

2.1 Toxicity Values

EPA toxicity values, known as non-carcinogenic reference doses (RfDs), non-carcinogenic reference concentrations (RfCs), and cancer slope factors (SFs) were obtained from USEPA’s Integrated Risk Information System (IRIS) on-line database (USEPA, 2008a), EPA’s Provisional Peer-Reviewed Toxicity Values Database (PPRTV) (USEPA, 2008b), USEPA’s National Center for Environmental Assessment (NCEA), USEPA’s Health Effects Assessment Summary Table (HEAST) (USEPA, 1997a), and other sources. The hierarchy for the sources of the toxicity values used to develop the NDEP screening table is as follows: (1) IRIS (indicated by “i” in the table), (2) PPRTV (“p”) and (3) NCEA (“n”), HEAST (“h”), and other documents (“o”). The OSWER Directive 9285.7-53 (dated December 5, 2003) (USEPA, 2003a) designates the hierarchy for toxicity criteria above.

The IRIS, PPRTV, and NCEA values are current as of 2008. HEAST has not been updated since the last screening-value table released in 1997 (USEPA, 1997a). HEAST values that have been externally peer reviewed are now in the PPRTV database and are noted by the letter “p” in the key column of the screening table next to the toxicity value. The PPRTV values currently represent the second tier of human health toxicity values for the USEPA Superfund and hazardous waste programs.

Route-to-route extrapolations (“r”) were used when toxicity values were not available for a given route of exposure. Oral cancer slope factors (“SFo”) and reference doses (“RfDo”) were used for both oral and inhalation exposures for organic compounds lacking inhalation values, where applicable. Inhalation cancer slope factors (“SF_i”) and inhalation reference doses (“RfDi”) were used for both inhalation and oral exposures for organic compounds lacking oral values, unless the toxicity data indicated otherwise. An additional route extrapolation that was applied is the use of oral toxicity values to evaluate dermal exposures.

In addition, due to the vast number of specialized compounds and analytical issues associated with the BMI Complex and Common Areas, toxicological surrogates have been derived for several compounds. The derivations for the toxicological surrogates are summarized in Appendix B.

2.2 Physical/Chemical Parameters

The physical/chemical data section of the spreadsheet provides the information needed to calculate the volatilization factors (VFs) and the saturation limits for the contaminants. Volatile chemicals are defined as those that have a Henry’s Law constant greater than 10^{-5} (atm·m³/mol) and a molecular weight less than 200 g/mole (USEPA, 1991). The emission terms used in the VFs are chemical specific and were calculated from physical/chemical information obtained from several sources: the 1996 *Soil Screening Guidance* (USEPA, 1996a, b), the 1996 *Superfund Chemical Data Matrix* (USEPA, 1996c), and the 1988 *Superfund Exposure Assessment Manual* (USEPA, 1988). The VF used to calculate the soil screening levels is derived in the physical/chemical data section of the spreadsheet, using the equation below, which is from the USEPA’s Soil Screening Guidance (USEPA, 1996a, b). The volatilization factor for water is not derived but is a constant.

2.3 Soil-to-Air Volatilization Factors (VFs)

Derivation of the Volatilization Factor

$$VF_s \left(\frac{m^3}{kg} \right) = \left(\frac{Q}{C} \right) \times \frac{(3.14 \times D_A \times T)^{1/2}}{(2 \rho_b \times D_A)} \times 10^{-4} \left(\frac{m^2}{cm^2} \right)$$

where:

$$D_A = \frac{(\Theta_a^{10/3} DiH' + \Theta_w^{10/3} Dw)/n^2}{p_b K_d + \Theta_w + \Theta_a H'}$$

Parameter	Definition (units)	Value
VF	Volatilization factor (m^3/kg)	Chemical specific
D_A	Apparent diffusivity (cm^2/s)	Chemical specific
Q/C	Inverse of the mean concentration at the center of a 0.5-acre square source ($\text{g}/\text{m}^2\text{-s}$ per kg/m^3)	68.81
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 ($L_{\text{air}}/L_{\text{soil}}$)	0.28 or $n - \Theta_w$
n	Total soil porosity ($L_{\text{pore}}/L_{\text{soil}}$)	0.43 or $1 - (\rho_b/\rho_s)$
Θ_w	Water-filled soil porosity ($L_{\text{water}}/L_{\text{soil}}$)	0.15
ρ_s	Soil particle density (g/cm^3)	2.65
D_i	Diffusivity in air (cm^2/s)	Chemical specific
H	Henry's Law constant	Chemical specific
H'	Dimensionless Henry's Law constant	Calculated from H by multiplying by 41 (USEPA, 1991)
D_w	Diffusivity in water (cm^2/s)	Chemical specific
K_d	Soil/water partition coefficient (cm^3/g) = $K_{oc}f_{oc}$	Chemical specific
K_{oc}	Soil organic carbon/water partition coefficient (cm^3/g)	Chemical specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.006 (0.6%)

Soil Saturation

The soil saturation concentration “sat” corresponds to the contaminant concentration in soil at which the absorptive limits of the soil particles, the solubility limits of the soil pore water, and saturation of soil-pore air have been reached. Above this concentration, the soil contaminant may be present in free phase (i.e., nonaqueous-phase liquids [NAPLs]) for contaminants that are liquid at ambient soil temperatures and in pure solid phases for compounds that are solid at ambient soil temperatures.

The equation below is used to calculate “sat” for each volatile contaminant. As an update to RAGS HHEM, Part B (USEPA 1991), this equation takes into account the amount of contaminant that is in the vapor phase in soil, in addition to the amount dissolved in the soil's pore water and sorbed to soil particles. The volatilization model is not applicable when free-phase contaminants are present. How these cases are handled depends on whether the contaminant is liquid or solid at ambient temperatures. Liquid contaminants for which screening levels exceed the “sat” concentration are set equal to “sat,” whereas for solids (e.g., polycyclic aromatic hydrocarbons [PAHs]), soil screening decisions are based on other appropriate pathways of concern at the site (e.g., ingestion and dermal contact).

2.4 Soil Saturation Concentration (sat)

Derivation of the Soil Saturation Limit

$$Sat = \frac{S}{\rho_b} (K_d \rho_b + \Theta_w + H'\Theta_a)$$

Parameter	Definition (units)	Value
Sat	Soil saturation concentration (mg/kg)	Calculated
S	Solubility in water (mg/L-water)	Chemical specific
ρ_b	Dry soil bulk density (kg/L)	1.5
K_d	Soil-water partition coefficient (L/kg)	$K_{oc} \times f_{oc}$ (chemical specific)
K_{oc}	Soil organic carbon/water partition coefficient (L/kg)	Chemical specific
f_{oc}	Fraction organic carbon content of soil (g/g)	0.006 or site specific
Θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15
Θ_a	Air-filled soil porosity (L_{air}/L_{soil})	0.28 or $n - \Theta_w$
n	Total soil porosity (L_{pore}/L_{soil})	0.43 or $1 - (\rho_b/\rho_s)$
ρ_s	Soil particle density (g/cm^3)	2.65
w	Average soil moisture content (kg_{water}/kg_{soil} or L_{water}/kg_{soil})	0.1
H	Henry's Law constant	Chemical specific
H'	Dimensionless Henry's Law constant	Calculated from H by multiplying by 41 (USEPA, 1991)

The physical/chemical parameters section of the spreadsheet also includes information on molecular weight and skin absorption factors used to calculate the dermal portion of the equations.

2.5 Dermal Absorption Factors

Chemical-specific dermal absorption factors for contaminants in soil and dust based on USEPA (2004; RAGS Part E, *Supplemental Guidance for Dermal Risk Assessment*) are presented in the BCL Table for arsenic, cadmium, chlordane, 2,4-D, DDT, Lindane, PAHs, pentachlorophenol, polychlorinated biphenyls (PCBs), and polychlorinated dibenzo-p-dioxins and dibenzofurans (collectively referred to as "dioxins"). For other chemicals, USEPA (2004) recommends using a default dermal absorption factor of 0.10 for semi-volatile organic chemicals. A default absorption factor for inorganics and volatile organic chemicals is no longer recommended. These USEPA dermal guidelines were applied to the BCLs.

2.6 Default Factors for Volatilization from Residential Water and Particulate Emissions from Soils

The physical/chemical data section of the spreadsheet does not calculate the particulate emission factor or the volatilization factor for residential water. Default values are used for these parameters which can be found in the spreadsheet above the header in the electronic Table.

Volatilization Factor for Residential Water

For residential water, an upper-bound volatilization constant (VF_w) is used that is based on all uses of household water (e.g., showering, laundering, and dish washing). Certain assumptions were made. For example, it is assumed that the volume of water used in a residence for a family of four is 720 L/day, the volume of the dwelling is 150,000 L, and the air exchange rate is 0.25 air changes/hour (Andelman, cited in USEPA, 1991; USEPA *Exposure Factors Handbook*, USEPA, 1997b). Furthermore, it is assumed that the average transfer efficiency, weighted by water use, is 50% (i.e., half the concentration of each chemical in water will be transferred into air by all water uses). The range of transfer efficiencies extends from 30% for toilets to 90% for dishwashers (Andelman, cited in USEPA, 1991). Volatilization was included in the residential water equations only for compounds with a "1" in the "VOC" column. The value used in calculating the screening level for residential water is 0.5 L/m³.

Particulate Emission Factor for Soils

To address the soil-to-air pathway for particulate emission, the screening-level calculations incorporate particulate emission factors (PEFs) for nonvolatile contaminants. The spreadsheet does not calculate a PEF, but uses the USEPA default PEF equal to 1.32×10^9 m³/kg (USEPA, 1996a). The default PEF relates the contaminant concentration in soil to the concentration of respirable particles in the air due to fugitive dust emissions from contaminated soils. The generic PEF was derived using default values that correspond to a receptor-point concentration of approximately 0.76 µg/m³. The relationship is derived by Cowherd (1985) for a rapid assessment procedure applicable to a typical hazardous waste site where the surface contamination provides a relatively continuous and constant potential for emission over an extended period of time (e.g., years). This represents an annual average emission rate based on wind erosion, which should be compared with chronic health criteria; it is not appropriate for evaluating the potential for acute exposures.

The PEF and associated inhalation dose do not appear to affect most soil screening levels significantly with the exception of specific metals. For more details regarding specific parameters used in the PEF model, the reader is referred to *Soil Screening Guidance: Technical Background Document* (USEPA 1996a).

Note: The default PEF evaluates windborne emissions only and does not consider dust emissions from traffic, or other forms of mechanical disturbance that are typical of short-term construction scenarios.

2.7 Age-Adjustment Factors

Because contact rates may be different for children and adults, carcinogenic risks during the first 30 years of life were calculated using age-adjusted factors (“adj”). Use of age-adjusted factors is especially important for soil ingestion exposures, which are higher during childhood and decrease with age. For purposes of combining exposures across pathways, additional age-adjusted factors are used for inhalation and dermal exposures. These factors approximate the integrated exposure from birth until age 30, combining contact rates, body weights, and exposure durations for two age groups □ small children and adults. Age-adjusted factors were obtained from USEPA RAGS Part B (USEPA, 1991) or developed by analogy. The equations depicted below are for carcinogens.

(1) ingestion for soil ([mg × yr]/[kg × d]):

$$IFSD_{adj} = \frac{ED_c \times IRS_c}{BW_c} + \frac{ED_r - ED_c \times IRS_a}{BW_a}$$

(2) skin contact ([mg × yr]/[kg × d]):

$$SFS_{adj} = \frac{ED_c \times AF \times SA_c}{BW_c} + \frac{(ED_r - ED_c) \times AF \times SA_a}{BW_a}$$

(3) inhalation ([m³ × yr]/[kg × d]):

$$InhF_{adj} = \frac{ED_c \times IRA_c}{BW_c} + \frac{(ED_r - ED_c) \times IRA_a}{BW_a}$$

(4) ingestion for water ([l × yr]/[kg × d])

$$InhF_{adj} = \frac{ED_c \times IRC_c}{BW_c} + \frac{(ED_r - ED_c) \times IRA_a}{BW_a}$$

The acronyms and their values are provided in Table 1. These values can also be found in the exposure default section of the BCL Table.

3.0 EXPOSURE-SPECIFIC/SCENARIO-SPECIFIC COMPARISON LEVELS

A BCL for each exposure pathway (ingestion, inhalation, and dermal), where applicable, is calculated separately for carcinogens and non-carcinogens, and is listed under the appropriate heading of residential, industrial-indoor, industrial-outdoor, ambient air, or residential water. Individual pathway values can provide important information with regard to risk drivers by comparing measurement data to relevant BCLs based on the carcinogenic risk and non-carcinogenic hazard. For the end user who may be using a cancer target risk level greater than 1×10^{-6} , the exposure-specific/scenario-specific section of the spreadsheet can be used to determine

whether the carcinogenic endpoint is more stringent than the non-carcinogenic endpoint, which is based on a hazard quotient of 1. The carcinogenic endpoint is not always the most conservative.

Default exposure factors used to develop the BCL values were obtained primarily from the USEPA Exposure Factors Handbook (USEPA, 1997b) and the USEPA Supplemental Soil Screening Guidance (USEPA, 2002). Table 1 lists all exposure factors used, their abbreviations used in the equations in this text, and the source. The equations for calculating the risk or hazard by exposure pathway, as well as the combined risk from all exposures for the scenario, are provided below.

3.1 Equations for Residential Land Use Scenario

Ingestion of Carcinogenic Contaminants in Soil

Eq. 1

$$\text{Comparison Level mg/kg} = \frac{\text{TR} \times \text{AT} \times 365 \text{ days/year}}{\text{SF}_o \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{IFS}_{adj}}$$

where:

- TR = Target risk of 10^{-6}
- AT = Averaging time (70 years)
- SF_o = Oral cancer slope factor
- EF = Exposure frequency (350 days)
- IFS_{adj} = Adjusted soil ingestion (mg-year)/(kg-day) = 114

Ingestion of Non-carcinogenic Contaminants

Eq. 2

$$\text{Comparison Level mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\frac{1}{\text{RfD}_o} \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{ED} \times \text{IRS}}$$

where:

- THQ = Target hazard quotient of 1
- BW = Body weight of child (15 kg)
- AT = Averaging time for child (6 years)
- RfD_o = Oral reference dose
- EF = Exposure frequency (350 days/year)
- ED = Exposure duration of child (6 years)
- IRS = Soil ingestion rate for child (200 mg/day)

Inhalation of Carcinogenic Contaminants

Eq. 3

$$\text{Comparison Level mg/kg} = \frac{\text{TR} \times \text{AT} \times 365 \text{ days/year}}{\text{SF}_i \times \text{EF} \times \text{InhF}_{adj} \times \left[\left(\frac{1}{\text{PEF}} \right) \text{ or } \left(\frac{1}{\sqrt{\text{VF}}} \right) \right]}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (70 years)
SF _i	=	Inhalation cancer slope factor (chemical-specific)
EF	=	Exposure frequency (350 days/year)
InhF _{adj}	=	Adjusted inhalation factor $11(\text{m}^3\text{-year})/(\text{kg}\text{-day})$
PEF	=	Particulate emission factor used for dusts ($1.32 \times 10^9 \text{ mg}^3/\text{kg}$)
VF	=	Volatilization factor used for volatile organic chemicals (mg^3/kg)

Inhalation of Non-carcinogenic Contaminants

Eq. 4

$$\text{Comparison Level mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\text{EF} \times \text{ED} \times \frac{1}{\text{RfD}_i} \times \text{IRA} \times \left[\left(\frac{1}{\text{PEF}} \right) \text{ or } \left(\frac{1}{\text{VF}} \right) \right]}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of child (15 kg)
AT	=	Averaging time for child (6 years)
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration for child (6 years)
RfD _i	=	Inhalation reference dose in $\text{mg}/\text{kg}/\text{day}$ (chemical specific)
IRA	=	Inhalation rate for child ($10 \text{ m}^3/\text{day}$)
PEF	=	Particulate emission factor used for dusts ($1.32 \times 10^9 \text{ m}^3/\text{kg}$)
VF	=	Volatilization factor used for volatile organic chemicals (m^3/kg)

Skin Contact of Carcinogenic Contaminants

Eq. 5

$$\text{Comparison Level mg/kg} = \frac{\text{TR} \times \text{AT} \times 365 \text{ days/year}}{\text{SF}_o \times \text{EF} \times \text{SFS}_{\text{adj}} \times \text{ABS} \times 10^{-6} \text{ kg/mg}}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (70 years)
SF _o	=	Oral cancer slope factor (chemical specific)
EF	=	Exposure frequency (350 days/year)
SFS _{adj}	=	Skin contact factor for soils ($361 \text{ mg}\text{-year}/\text{kg}\text{-day}$)
ABS	=	Skin absorption (chemical specific)

Skin Contact of Non-carcinogenic Contaminants

Eq. 6

$$\text{Comparison Level mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ day/year}}{\text{EF} \times \text{ED} \times \frac{1}{\text{RfD}_o} \times 10^{-6} \text{ kg/mg} \times \text{SA} \times \text{AF} \times \text{ABS}}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of child (15 kg)
AT	=	Averaging time of child (6 years)
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration of child (6 years)
RfD _o	=	Oral reference dose (chemical-specific)
SA	=	Surface area of child (2800 cm ² /day)
AF	=	Adherence factor of child (0.2 mg/cm ²)
ABS	=	Skin absorption (chemical specific)

Comparison Level for Combined Exposure Pathways for Carcinogenic Contaminants for Residential Receptor

Eq. 7

$$\text{Comparison Level mg/kg} = \frac{1}{\frac{1}{\text{Eq. 1}} + \frac{1}{\text{Eq. 3}} + \frac{1}{\text{Eq. 5}}}$$

Comparison Level for Combined Exposure Pathways for Non-carcinogenic Contaminants for Residential Receptor-

Eq. 8

$$\text{Comparison Level mg/kg} = \frac{1}{\frac{1}{\text{Eq. 2}} + \frac{1}{\text{Eq. 4}} + \frac{1}{\text{Eq. 6}}}$$

Equation 4 for uses the PEF approach for solids and the VF approach for volatile compounds.

3.2 Equations for the Industrial Indoor Worker Scenario

Ingestion of Carcinogenic Contaminants

Eq. 9

$$\text{Comparison Level mg/kg} = \frac{\text{TR} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\text{SF}_o \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{ED} \times \text{IRS}}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (70 years)
BW	=	Body weight of adult (70 kg)
SF _o	=	Oral cancer slope factor (chemical specific)
EF	=	Exposure frequency (250 days/year)
ED	=	Exposure duration (25 years)
IRS	=	Soil ingestion rate for adult (50 mg/day)

Ingestion of Non-carcinogenic Contaminants

Eq. 10

$$\text{Comparison Level mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\frac{1}{\text{RfD}_o} \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{ED} \times \text{IRS}}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time (25 years)
RfD _o	=	Oral reference dose (chemical specific)
EF	=	Exposure frequency (250 days/year)
ED	=	Exposure duration (25 years)
IRS	=	Ingestion rate for soil (50 mg/day)

Inhalation of Carcinogenic Contaminants

Eq. 11

$$\text{Comparison Level mg/kg} = \frac{\text{TR} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\text{SF}_i \times \text{EF} \times \text{ED} \times \text{IRA} \times \left[\left(\frac{1}{\text{PEF}} \right) \text{ or } \left(\frac{1}{\text{VF}} \right) \right]}$$

where:

TR	=	Target risk of 10^{-6}
BW	=	Body weight of adult (70kg)
AT	=	Averaging time (70 years)
SF _i	=	Inhalation cancer slope factor (chemical-specific)
EF	=	Exposure frequency (250 days/year)
ED	=	Exposure duration (25 years)
IRA	=	Inhalation rate (20 m ³ /day)
PEF	=	Particulate emission factor used for dusts (1.32×10^9 m ³ /kg)
VF	=	Volatilization factor used for volatile organic chemicals (m ³ /kg)

Inhalation of Non-carcinogenic Contaminants

Eq. 12

$$\text{Comparison Level mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\text{EF} \times \text{ED} \times \left(\frac{1}{\text{RfD}_i}\right) \times \text{IRA} \times \left[\left(\frac{1}{\text{PEF}}\right) \text{ or } \left(\frac{1}{\text{VF}}\right)\right]}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time (25 years)
EF	=	Exposure frequency (250 days/year)
ED	=	Exposure duration (25 years)
RfD _i	=	Inhalation reference dose in mg/kg/day (chemical specific)
IRA	=	Inhalation rate of adult (20 m ³ /day)
PEF	=	Particulate emission factor used for dusts (1.32×10 ⁹ m ³ /kg)
VF	=	Volatilization factor used for volatile organic chemicals (mg ³ /kg)

Comparison Level for Combined Exposure Pathways for Carcinogenic Contaminants for Indoor Industrial Worker

Eq. 13

$$\text{Comparison Level mg/kg} = \frac{1}{\frac{1}{\text{Eq. 9}} + \frac{1}{\text{Eq. 11}}}$$

Comparison Level for Combined Exposure Pathways for Non-carcinogenic Contaminants for Indoor Industrial Worker-

Eq. 14

$$\text{Comparison Level mg/kg} = \frac{1}{\frac{1}{\text{Eq. 10}} + \frac{1}{\text{Eq. 12}}}$$

3.3 Equations for the Industrial -Outdoor Worker Scenario

Ingestion of Carcinogenic Contaminants

Eq. 15 Screening

$$\text{Comparison Level mg/kg} = \frac{\text{TR} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\text{SF}_0 \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{ED} \times \text{IRS}}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (70 years)
BW	=	Body weight of adult (70kg)
SF _o	=	Oral cancer slope factor (chemical-specific)
EF	=	Exposure frequency (225 days/year)
ED	=	Exposure duration (25 years)
IRS	=	Soil ingestion rate for adult (100 mg/day)

Ingestion of Non-carcinogenic Contaminants

Eq. 16

$$\text{Comparison Level mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\frac{1}{\text{RfD}_o} \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{ED} \times \text{IRS}}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time (25 years)
RfD _o	=	Oral reference dose (chemical-specific)
EF	=	Exposure frequency (225 days/year)
ED	=	exposure duration (25 years)
IRS	=	Soil ingestion rate for adult (100 mg/day)

Inhalation of Carcinogenic Contaminants

Eq. 17

$$\text{Comparison Level mg/kg} = \frac{\text{TR} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\text{SF}_i \times \text{EF} \times \text{ED} \times \text{IRA} \times \left[\left(\frac{1}{\text{PEF}} \right) \text{ or } \left(\frac{1}{\text{VF}} \right) \right]}$$

where:

TR	=	Target risk of 10^{-6}
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time (70 years)
SF _i	=	Inhalation cancer slope factor (chemical specific)
EF	=	Exposure frequency (225 days/year)
ED	=	Exposure duration (25 years)
IRA	=	Inhalation rate for adult (20 m ³ /day)
PEF	=	Particulate emission factor used for dusts (1.32×10^9 m ³ /kg)
VF	=	Volatilization factor used for volatile organic chemicals (m ³ /kg)

Inhalation of Non-carcinogenic Contaminants

Eq.18

$$\text{Comparison Level mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\text{EF} \times \text{ED} \times \left(\frac{1}{\text{RfD}_i}\right) \times \text{IRA} \times \left[\left(\frac{1}{\text{PEF}}\right) \text{ or } \left(\frac{1}{\text{VF}}\right)\right]}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time (25 years)
EF	=	Exposure frequency (225 days/year)
ED	=	Exposure duration (25 years)
RfD _i	=	Inhalation reference dose in mg/kg/day (chemical specific)
IRA	=	Inhalation rate of adult (20 m ³ /day)
PEF	=	Particulate emission factor used for dusts (1.32×10 ⁹ m ³ /kg)
VF	=	Volatilization factor used for volatile organic chemicals (m ³ /kg)

Skin Contact with Carcinogenic Contaminants

Eq. 19

$$\text{Comparison Level mg/kg} = \frac{\text{TR} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\text{EF} \times \text{ED} \times \text{SF}_o \times 10^{-6} \text{ kg/mg} \times \text{SA} \times \text{AF} \times \text{ABS}}$$

where:

TR	=	Target risk of 10 ⁻⁶
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time of worker (25 years)
EF	=	Exposure frequency (225 days/year)
ED	=	Exposure duration of worker (25 years)
SF _o	=	Oral cancer slope factor (chemical specific)
SA	=	Surface area exposed for adult (3300 cm ² /day)
AF	=	Adherence factor (0.2 mg/cm ²)
ABS	=	Skin absorption (chemical specific)

Skin Contact with Non-carcinogenic Contaminants

Eq. 20

$$\text{Comparison Level mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\text{EF} \times \text{ED} \times \frac{1}{\text{RfD}_o} \times 10^{-6} \text{ kg/mg} \times \text{SA} \times \text{AF} \times \text{ABS}}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time of outdoor worker (25 years)
EF	=	Exposure frequency (225 days/year)
ED	=	Exposure duration of worker (25 years)
RfD _o	=	Oral reference dose (chemical specific)
SA	=	Surface area exposed for adult (3300 cm ² /day)
AF	=	Adherence factor (0.2 mg/cm ²)
ABS	=	Skin absorption (chemical-specific)

Comparison Level for Combined Exposure Pathways for Carcinogenic Contaminants for Outdoor Industrial Worker

Eq. 21

$$\text{Comparison Level mg/kg} = \frac{1}{\frac{1}{\text{Eq. 15}} + \frac{1}{\text{Eq. 17}} + \frac{1}{\text{Eq. 19}}}$$

Comparison Level for Combined Exposure Pathways for Non-carcinogenic Contaminants for Outdoor Industrial Worker

Eq. 22

$$\text{Comparison Level mg/kg} = \frac{1}{\frac{1}{\text{Eq. 16}} + \frac{1}{\text{Eq. 18}} + \frac{1}{\text{Eq. 20}}}$$

3.4 Ambient Air Equations

Inhalation of Carcinogenic Contaminants

Eq. 23

$$\text{Comparison Level } (\mu\text{g}/\text{m}^3) = \frac{\text{TR} \times \text{AT} \times 365 \text{ days/year} \times 1,000 \mu\text{g}/\text{mg}}{\text{EF} \times \text{InhF}_{\text{adj}} \times \text{SF}_o}$$

where:

TR	=	Target risk of 10 ⁻⁶
AT	=	Averaging time (70 years)
EF	=	Exposure frequency (350 days/year)
InhF _{adj}	=	Adjusted inhalation factor (11 m ³ -year/kg-day)
SF _o	=	Oral cancer slope factor (chemical specific)

Inhalation of Non-carcinogenic Contaminants

Eq.24

$$\text{Comparison Level } (\mu\text{g}/\text{m}^3) = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ days/year} \times 1,000 \mu\text{g}/\text{mg}}{\text{EF} \times \text{ED} \times \text{IRA} \times \frac{1}{\text{RfD}_i}}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time of resident (30 years)
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration (30 years)
IRA	=	Inhalation rate (20 m ³ /day)
RfD _i	=	Inhalation reference dose (chemical-specific)

3.5 Residential Water Equations

Ingestion and Inhalation of Carcinogenic Contaminants

Eq. 25

$$\text{Comparison Level } (\mu\text{g}/\text{l}) = \frac{\text{TR} \times \text{AT} \times 365 \text{ days/year} \times 1,000 \mu\text{g}/\text{mg}}{\text{EF} \times [(\text{IFW}_{\text{adj}} \times \text{SF}_o) + (\text{VF} \times \text{InhF}_{\text{adj}} \times \text{SF}_i)^*]}$$

where:

TR	=	Target risk of 10 ⁻⁶
AT	=	Averaging time (70 years)
EF	=	Exposure frequency (350 days/year)
IFW _{adj}	=	Ingestion factor for water (1.1 L-year/kg-day)
SF _o	=	Oral cancer slope factor (chemical specific)
VF	=	Volatilization factor for water (0.5 L/m ³)
InhF _{adj}	=	Adjusted inhalation factor (11 m ³ -yr/kg-day)
SF _i	=	Inhalation cancer slope factor (chemical specific)

* Inhalation component of the equation is calculated only for volatile organic chemicals.

Ingestion and Inhalation of Non-carcinogenic Contaminants

Eq. 26

$$\text{Comparison Level } \mu\text{g}/\text{L} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ days/year} \times 1,000 \mu\text{g}/\text{mg}}{\text{EF} \times \text{ED} \left[\left(\frac{\text{IRW}}{\text{RfD}_o} \right) + \left(\text{VF} \times \text{IRA} \times \frac{1}{\text{RfD}_i} \right)^* \right]}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time of resident (30 years)
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration (30 years)
IRW	=	Drinking water ingestion (2 L/day)
RfD _o	=	Oral reference dose (chemical specific)
VF	=	Volatilization factor for water (0.5 L/m ³)
IRA	=	Inhalation rate (20 m ³ /day)
RfD _i	=	Inhalation reference dose (chemical specific)

* Inhalation part of equation only calculated for volatile organic chemicals

Table 1 provides the Standard Default Exposure Factors used in the preceding equations.

Development of Final Residential Soil BCLs in the Absence of an RfC

Several values are compared in order to develop the final comparison level. These include the comparison to a maximum of 100,000 for the less toxic chemicals, and to the soil saturation limit. These equations are listed below.

If the contaminant is a solid, the following applies:

Eq. 27a: Comparison Level (mg/kg) = Minimum value from Eq. 7, Eq. 8*, or 100,000
*Equation 8 uses the Eq. 4 option.

If the contaminant is not a solid, the following applies:

Eq. 27b Comparison Level (mg/kg) = Minimum value from saturation, Eq. 7, Eq. 8*, or 100,000
*Equation 8 uses the Eq. 4 option.

Residential Soil Value when RfC is Available

If the contaminant is a solid, the following applies:

Eq. 27a Comparison Level (mg/kg) = Minimum value from Eq. 7, Eq. 8*, or 100,000
*Equation 8 uses the Eq. 4 option.

If the contaminant is not a solid, then the following applies:

Eq. 27b Comparison Level (mg/kg) = Minimum value from saturation, Eq. 7, Eq. 8*, or 100,000
*Equation 8 uses the Eq. 4 option.

Industrial Soil Indoor Worker

If the contaminant is a solid, the following applies:

$$\text{Eq. 28a} \quad \text{Comparison Level (mg/kg)} = \text{Minimum value from Eq. 13, Eq. 14, or 100,000}$$

If the contaminant is not a solid, the following applies:

$$\text{Eq. 28b} \quad \text{Comparison Level (mg/kg)} = \text{Minimum value from saturation, Eq. 13, Eq. 14, or 100,000}$$

Industrial Soil Outdoor Worker

If the contaminant is a solid, the following applies:

$$\text{Eq. 29a} \quad \text{Comparison Level (mg/kg)} = \text{Minimum value from Eq. 21, Eq. 22, or 100,000}$$

If the contaminant is not a solid, the following applies:

$$\text{Eq. 29b} \quad \text{Comparison Level (mg/kg)} = \text{Minimum value from saturation, Eq. 21, Eq. 22, or 100,000}$$

Ambient Air

$$\text{Eq. 30} \quad \text{Comparison Level } (\mu\text{g}/\text{m}^3) = \text{Minimum value from Eq. 23 or Eq. 24}$$

Residential Water

$$\text{Eq. 31} \quad \text{Comparison Level } (\mu\text{g}/\text{L}) = \text{Minimum value from Eq. 25 or Eq. 26}$$

3.6 Special Considerations

3.6.1 Screening with Multiple Contaminants

A suggested stepwise approach for BCL-screening of sites with multiple pollutants is as follows:

- Perform an extensive records search and compile existing data.
- Use the CSM to identify all known and potential site contaminants in the BCL Table. Record the BCL concentrations for various media and note whether the chemical has been assigned cancer (indicated by “ca”) and/or non-cancer (indicated by “nc”) toxicological criteria. Segregate cancer BCLs from non-cancer BCLs and exclude (but do not eliminate) non-risk based BCLs (“sat” or “max”).

- For cancer risk estimates, take the site-specific concentration (maximum or 95 UCL) and divide by the BCL concentration designated for cancer evaluation (“ca”). Multiply this ratio by 10^{-6} to estimate chemical-specific risk for a reasonable maximum exposure (RME). For multiple pollutants, simply add this risk estimate for each chemical as follows:

$$Risk = \left[\left(\frac{Conc_x}{BCL_x} \right) + \left(\frac{Conc_y}{BCL_y} \right) + \dots + \left(\frac{Conc_z}{BCL_z} \right) \right] \times 10^{-6}$$

- For non-cancer hazard estimates, divide the site exposure point concentration term by the respective non-cancer BCL (designated as “nc”) and sum the ratios for multiple contaminants. The cumulative ratio represents a screening non-cancer hazard index (HI). A screening hazard index of 1 or less is considered “safe”. A ratio greater than 1 suggests further evaluation (see USEPA, 1989, page 8-14 for segregation of hazard indices by effect and mechanism of action). [Note that carcinogens may also have an associated non-cancer BCL that is not listed in the BCL Table. To obtain these values, the user should view or download the BCL Detail Tables at the BCL website and display the appropriate sections.]

$$Hazard\ Index = \left[\left(\frac{Conc_x}{BCL_x} \right) + \left(\frac{Conc_y}{BCL_y} \right) + \dots + \left(\frac{Conc_z}{BCL_z} \right) \right]$$

For initial screening of data when multiple chemicals have been released, a simplified conservative approach of employing one-tenth of the BCL can be applied.

3.6.2 Evaluating Migration of Soil Chemicals to Groundwater: Leaching-Based BCLs (LBCLs)

The method for calculating leaching-based soil screening levels (LBCLs) for migration to groundwater was developed to identify chemical concentrations in soil that have the potential to contaminate groundwater. Migration of contaminants from soil to groundwater is evaluated as a two-stage process: (1) release of contaminant in soil leachate, and (2) transport of the contaminant through the underlying soil and aquifer to a receptor well. The LBCL methodology considers both of these transport mechanisms.

LBCLs are back-calculated from acceptable groundwater concentrations (i.e., non-zero MCLGs, MCLs, or risk-based screening levels). Residential exposure scenarios are assumed based on a fixed upper-bound risk of 10^{-6} or a fixed hazard quotient of 1. First, the acceptable groundwater concentration is multiplied by a dilution factor to obtain a target leachate concentration. For example, if the dilution factor is 10 and the acceptable groundwater concentration is 0.05 mg/L, the target soil leachate concentration would be 0.5 mg/L. The partition equation (presented in USEPA, 1996a) is then used to calculate the total soil concentration that corresponds to this soil leachate concentration. The BCL Table presents the dilution-attenuation factors (DAF) for relevant chemicals, which can be used to calculate the LBCL. Due to rounding, there may be some slight difference in the Table values and the values found in the *Soil Screening Guidance* (USEPA, 1996a).

3.6.3 BCLs for Chemicals with Special Considerations

Polycyclic aromatic hydrocarbons, and polychlorinated dibenzo-p-dioxins, dibenzofurans, and dioxin-like (coplanar) polychlorinated biphenyls, are chemical mixtures for which alternative approaches have been developed by USEPA to simplify risk calculations using a toxicity-equivalence factor approach. In addition, special conditions for certain metals, inorganics, total petroleum hydrocarbons, and vinyl chloride have been adopted by USEPA Region 9 (USEPA, 2004b, 2008c) and are also considered appropriate with respect to BCLs, as explained below.

Cadmium

Because IRIS provides different oral RfDs for cadmium in water and in foods, the BCL for cadmium in water is based on the oral RfD for water, and the BCL for soil ingestion is based on the RfD for foods.

Lead

The residential soil value for lead is based on the Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead in children developed using default parameters (USEPA, 1994). More information on this model and other lead risk assessment guidance can be found at <http://www.epa.gov/superfund/health/contaminants/lead/index.htm>. The industrial BCL is based on equations developed by the technical review group (adult lead model), as described below.

The Adult Lead Model (ALM) is a tool for assessing risks associated with **non-residential** adult exposures to lead in soil. The ALM focuses on estimating fetal blood lead concentrations in pregnant women exposed to lead-containing soils in a commercial/industrial setting. It is the product of extensive evaluations by the Technical Review Workgroup for Lead (TRW). In December 1996, the TRW released the document *Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil (TRWR; USEPA, 1996d)*, which describes the equations and default parameters that can be used with the ALM.

Manganese

The IRIS RfD (0.14 mg/kg-day) includes manganese from all sources, including the diet. The IRIS assessment on manganese recommends that the dietary contribution from the normal U.S. diet (an upper limit of 5 mg/day) be subtracted when evaluating non-food (e.g., drinking water or soil) exposures to manganese, leading to an RfD of 0.071 mg/kg-day for non-food items. The explanatory text in IRIS further recommends using a modifying factor of 3 when calculating risks associated with non-food sources, due to a number of uncertainties that are discussed in the IRIS file for manganese, leading to an RfD of 0.024 mg/kg-day. This modified RfD is applied in the derivation of manganese BCLs for soil and water.

Nitrates/Nitrites

Tap-water BCLs for nitrates/nitrites are based on the MCL, because there is no available RfD for these compounds. For more information, please see IRIS (USEPA, 2008a) at: <http://www.epa.gov/iris>.

Vinyl Chloride

IRIS (USEPA, 2008a) presents two cancer slope factors for vinyl chloride—one for adult exposures and a second, more protective, slope factor to account for the unique susceptibility identified in young animals that suggests a greater susceptibility to vinyl chloride carcinogenicity in young children. The more conservative factor for children is applied for the BCL corresponding to residential vinyl chloride exposure scenarios, and includes an assumption of lifetime (70 years) exposure for residential receptors as an added conservative measure based on USEPA Region 9 recommendations. The adult exposure cancer slope factor is used as the basis for the commercial/industrial BCL.

Chemicals for Which the BCL is Based on a Toxicological Surrogate

BCLs for the following chemicals are based on a toxicological surrogate approach:

- Acenaphthalene
- Benzo[g,h,i]perylene
- Phenanthrene
- Diethyl phosphorodithioate(DEPT)
- Dimethyl phosphorodithioate (DMPT)
- m-Phthalic acid
- o-Phthalic acid
- p-Chlorobenzene sulfonic acid (pCBSA)
- Benzene sulfonic acid (BSA)

Documentation of the basis of the surrogate selection for each of these chemicals is provided in Appendix B.

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**Table 1. Standard Default Exposure Parameters
NDEP Basic Comparison Levels**

Abbreviation	Definition	Parameter Value	Reference
Sfo	Cancer slope factor, oral; (mg/kg-d) ⁻¹	Chemical Specific	IRIS, PPRTV, NCEA, HEAST or Other Document
SFi	Cancer slope factor inhalation (mg/kg-d) ⁻¹	Chemical Specific	IRIS, PPRTV, NCEA, HEAST or Other Document
RfDo	Reference dose oral (mg/kg-d)	Chemical Specific	IRIS, PPRTV, NCEA, HEAST or Other Document
RfDi	Reference dose inhalation (mg/kg-d)	Chemical Specific	IRIS, PPRTV, NCEA, HEAST or Other Document
RfC	Reference concentration (mg/m ³)	Chemical Specific	IRIS, PPRTV, NCEA, HEAST or Other Document
TR	Target cancer risk	10 ⁻⁶	--
THQ	Target hazard quotient	1	--
BWa	Body weight, adult (kg)	70	RAGS Part A, USEPA 1989
BWc	Body weight, child (kg)	15	Exposure Factors Handbook USEPA, 1997b
ATc	Averaging time - carcinogens (days)	25550	RAGS Part A, USEPA 1989
ATn	Averaging time - noncarcinogens (days)	ED*365	
SAa	Exposed surface area, adult (cm ² /day)	5700	RAGS Part E, USEPA 2004
SAc	Exposed surface area, child (cm ² /day)	2800	RAGS Part E, USEPA 2004
SAao	Exposed surface area, outdoor worker (cm ² /day)	3300	RAGS Part E, USEPA 2004
AFa	Adherence factor, adult (mg/cm ²)	0.07	RAGS Part E, USEPA 2004
AFw	Adherence factor, adult-work (mg/cm ²)	0.2	RAGS Part E, USEPA 2004
AFc	Adherence factor, child (mg/cm ²)	0.2	RAGS Part E, USEPA 2004
ABS	Skin absorption (unit less):		
	-- volatile organics/inorganics	none	RAGS Part E, USEPA 2004
	-- semi-volatile organics	0.1	RAGS Part E, USEPA 2004
IRa	Inhalation rate - adult (m ³ /day)	20	Exposure Factors Handbook USEPA, 1997b
IRc	Inhalation rate - child (m ³ /day)	10	Exposure Factors Handbook USEPA, 1997b
IRWa	Drinking water ingestion - adult (L/day)	2	RAGS Part A, USEPA 1989
IRWc	Drinking water ingestion - child (L/day)	1	Exposure Factors Handbook USEPA, 1997b
IRSa	Soil ingestion - adult (resident and outdoor worker-mg/day)	100	Exposure Factors Handbook USEPA, 1997b
IRSc	Soil ingestion - child (mg/day),	200	Exposure Factors Handbook USEPA, 1997b
IRSo	Soil ingestion - indoor worker (mg/day)	50	Exposure Factors Handbook USEPA, 1997b
Efr	Exposure frequency - residential (d/y)	350	Exposure Factors Handbook USEPA, 1997b
Efo	Exposure frequency - outdoor worker (d/y)	250	Exposure Factors Handbook USEPA, 1997b
Efout	Exposure frequency- outdoor worker (d/y)	225	Supplemental Soil Screening Guidance, USEPA 2002
EDr	Exposure duration - residential (years)	30 ^a	Exposure Factors Handbook USEPA, 1997b
EDc	Exposure duration - child (years)	6	Exposure Factors Handbook USEPA, 1997b
EDo	Exposure duration - occupational (years)	25	Exposure Factors Handbook USEPA, 1997b
VFw	Volatilization factor for water (L/m ³)	0.5	RAGS Part B, USEPA 1991
PEF	Particulate emission factor (m ³ /kg)	1.32E+09	Soil Screening Guidance USEPA 1996a
VFs	Volatilization factor for soil (m ³ /kg)	Chemical Specific	Soil Screening Guidance USEPA 1996a
sat	Soil saturation concentration (mg/kg)	Chemical Specific	Soil Screening Guidance USEPA 1996a
Age-adjusted factors for carcinogens:			
IFSadj	Ingestion factor, soils ([mg × yr]/ [kg × d])	114	RAGS Part B, USEPA 1991
SFSadj	Skin contact factor, soils ([mg × yr]/ [kg × d])	361	By analogy to RAGS Part B, USEPA, 1991
InhFadj	Inhalation factor ([m ³ × yr]/ [kg × d])	11	By analogy to RAGS Part B, USEPA, 1991
IFWadj	Ingestion factor, water ([l × yr]/ [kg × d])	1.1	By analogy to RAGS Part B, USEPA, 1991

Footnote:

^aExposure duration for lifetime residents is assumed to be 30 years total (USEPA, 1989). For carcinogens, exposures are combined for children (6 years) and adults (24 years).

Appendix A

Annotation of Changes to the BCL Table Versus Time

Appendix B

Documentation for Toxicological Surrogates

TABLE B-1 TOXICOLOGICAL SURROGATES APPLIED FOR BCLS

Chemical	CAS #	Surrogate	Surrogate CAS Number	Oral RfD (mg/kg-day)	Inhalation RfD (mg/kg-day)
Acenaphthalene	208-96-8	pyrene	129-00-0	3.0×10^{-2} (IRIS)	3.0×10^{-2} (route extrapolation)
Benzo[g,h,i]perylene	191-24-2	pyrene	129-00-0	3.0×10^{-2} (IRIS)	3.0×10^{-2} (route extrapolation)
Phenanthrene	85-01-8	pyrene	129-00-0	3.0×10^{-2} (IRIS)	3.0×10^{-2} (route extrapolation)
Diethyl phosphorodithioate (DEPT)	298-06-6	diisopropyl methylphosphonate (DIMP)	1445-75-6	8.0×10^{-2} (Integral, 2006; NDEP, 2007)	8.0×10^{-2} (route extrapolation)
Dimethyl phosphorodithioate (DMPT)	756-80-9	isopropyl methylphosphonate (IMPA)	1832-54-8	1.0×10^{-1} (Integral, 2006; NDEP, 2007)	1.0×10^{-1} (route extrapolation)
m-Phthalic acid	121-91-5	phthalic anhydride	85-44-9	2.0×10^0 (IRIS)	3.4×10^{-2} (HEAST)
o-Phthalic acid	88-99-3	phthalic anhydride	85-44-9	2.0×10^0 (IRIS)	3.4×10^{-2} (HEAST)
p-Chlorobenzene sulfonic acid (pCBSA)	98-66-8	NA (RfD based on pCBSA study)	NA	1.0×10^0 (derived by Integral, 2007)	1.0×10^0 (route extrapolation)
Benzene sulfonic acid (BSA)	98-11-3	p-toluenesulfonic acid (pTSA)	104-15-4	5.0×10^{-1} (derived by Integral, 2007)	5.0×10^{-1} (route extrapolation)

Integral Consulting, Inc., 2006. Development of Human Health Toxicological Criteria for DMPT and DEPT, October 31.

[http://ndep.nv.gov/bmi/docs/061031%20surrogate toxicity report 20061031 final integral.pdf](http://ndep.nv.gov/bmi/docs/061031%20surrogate%20toxicity%20report%2020061031%20final%20integral.pdf)

Integral Consulting, Inc., 2007. Toxicological Profiles for Three Organic Acids, November 16, 2007 (p. 3-3).

<http://ndep.nv.gov/bmi/docs/071116-organicacidprofiles.pdf>

TABLE B-1 TOXICOLOGICAL SURROGATES APPLIED FOR BCLS

NDEP, 2007. NDEP concurrence regarding the derivation of toxicological surrogates for DEPT and DMPT, February 12.
http://ndep.nv.gov/bmi/docs/070212_dmpt_dept.pdf

Note: all surrogate derivations can be found at <http://ndep.nv.gov/bmi/technical.htm> under “Toxicology”.