MATERIAL ADOPTED BY REFERENCE, DEPARTMENT OF ENVIRONMENTAL CONSERVATION REGULATIONS RE: CONTAMINATED SITE CLEANUP PROCEDURES AND SOIL AND GROUNDWATER CLEANUP LEVELS (DEP'T OF LAW FILE NO. JU2015200567)

Eff. 11/6/2016, Register 220

MATERIAL ADOPTED BY REFERENCE
DEPARTMENT OF ENVIRONMENTAL
CONSERVATION REGULATIONS TO
CONTAMINATED SITE CLEANUP
PROCEDURES AND SOIL AND
GROUNDWATER CLEANUP LEVELS
(DEPT OF LAW FILE NO. J2013200567)

BY: _____, Registrar

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Spill Prevention and Response
Contaminated Sites Program

Procedures for Calculating Cleanup Levels
September 15, 2016

Adopted by Reference at 18 AAC 75

Procedures for Calculating Cleanup Levels

TABLE OF CONTENTS

1.0 Introduction

State of Alaska Regulations at 18 AAC 75, Article 3, for Oil and Other Hazardous Substances Pollution Control, govern the cleanup of sites contaminated with oil or other hazardous substances. Sections of this regulation address the selection or development of cleanup levels for contaminated soil and groundwater that are considered protective of human health, safety, and welfare, and the environment. Cleanup levels at a site may be determined by one or more of four methods.

Method one cleanup levels listed in 18 AAC 75.341(a) and (b) apply only to soil contaminated with petroleum hydrocarbons and are not considered risk-based. Method two cleanup levels for approximately 180 chemicals are listed in 18 AAC 75.341(c) and for petroleum hydrocarbons in 18 AAC 75.341(d). These levels are generally risk-based, incorporating toxicity and chemical specific information, assessing multiple routes of exposure in climate settings that reflect the variability found across the state, and the potential for a given chemical to migrate from soil to groundwater. However, if the risk-based cleanup level exceeds the soil saturation or water solubility limit, the cleanup level is set at that limit in compliance with 18 AAC 75.325(f), which requires free product recovery. Though still somewhat generic, the method two levels are considered protective of human exposure for most sites. Determining cleanup levels under method three allows for modification of the default soil cleanup levels to account for site-specific soil and aquifer data or to propose a commercial/industrial exposure scenario. Method four cleanup levels are developed under a risk assessment conducted in accordance with the department's Risk Assessment Procedures Manual (ADEC, 2015).

This document presents the equations used to calculate the default, method two soil cleanup criteria listed in Tables B1 and B2 in 18 AAC 75.341(c) and (d) and groundwater criteria listed in Table C in 18 AAC 75.345(b)(1). The equations presented in Sections 2.0 through 5.0 for individual organic and inorganic chemicals are based on those developed for the Regional Screening Levels (RSLs) by the Oak Ridge National Laboratory under contract to the United States Environmental Protection Agency (EPA), but adapted for Alaska to account for soil and climate variability, and a default cancer risk of 1:100,000.

The equations presented in Section 6.0 for the petroleum fractions are unchanged from the 2008 version of this document. These equations were developed using the 1996 EPA Soil Screening Guidance (U.S. EPA 1996a) and information generated by the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG, 1997).

Equations are provided for the residential land use scenario only; commercial/industrial land use scenarios must be proposed under a method three (18 AAC 75.340(e)). Procedures for calculating site-specific soil cleanup levels for both Table B1 chemicals and Table B2 petroleum fractions under method three are detailed in Section 7.0.

The standardized default exposure and soil parameters developed by EPA have been used except where noted (See Table 8 for the Standard Default Parameters, found in Appendix B). These exposure parameters are designed to be protective for reasonable maximum exposure (RME)

conditions for long-term/chronic exposures, (U.S. EPA. 1991a; U.S. EPA. 1996a; U.S. EPA. 2002). Chronic oral reference doses (RfD) and chronic inhalation reference concentrations (RfC) are used to calculate non-carcinogenic concentrations. Chronic oral slope factors (CSF_o) are used to evaluate potential human carcinogenic risks. A lifetime cancer risk factor of 1×10^{-5} is used, along with a target hazard quotient (THQ) of 1, reported to one significant figure, for noncarcinogens.

For Table B1 and C compounds – equations are presented for non-carcinogenic compounds, carcinogenic compounds, and mutagenic compounds for soil and for groundwater. In addition, for vinyl chloride and trichloroethylene (TCE) in soil and groundwater, a unique set of equations are provided that adjust for early-life cancer risk estimates to derive the cleanup levels.

The groundwater cleanup calculations (Section 2.0) are broken down into equations for ingestion of groundwater, dermal contact with groundwater, and inhalation of volatiles from groundwater. The soil exposure pathway calculations (Section 3.0) are broken down into equations for dermal contact with soil, soil ingestion, and inhalation of volatiles and inhalation of soil particulates using a particulate emission factor (PEF) equation (See Section 5.0, supporting equations). Compounds considered volatile for including the inhalation pathway, are those chemicals with a Henry's Law constant greater than or equal to 1×10^{-5} atm-m^3/mole[1] or a vapor pressure greater than or equal to 1 mm Hg.

For the ingestion route, equations use an age-adjusted approach to account for the variation in soil ingestion rates for children depending on age. A number of studies have shown that inadvertent ingestion of soil is common among children six years old and younger (Calabrese et al. 1989, Davis et al. 1990, Van Wijnen et al. 1990). Therefore, the dose method uses an age-adjusted soil ingestion factor that takes into account the difference in daily soil ingestion rates, body weights, and exposure duration for children from 1 to 6 years old and others from 7 to 30 years old. This health-protective approach is chosen to take into account the higher daily rates of soil ingestion in children as well as the longer duration of exposure that is anticipated for a long-term resident. For more on this method, see RAGS Part B (U.S. EPA. 1991a).

The Table B1 method two residential soil cleanup level for the human health pathway provides a single cleanup value that does not exceed a cumulative cancer risk value of 1×10^{-5} or a THQ of 1 reported to one significant figure for noncarcinogens for all three soil exposure pathways. Likewise, the Table C groundwater cleanup value is generated by a cumulative risk calculation.

The migration to groundwater criteria for the Table B1 compounds are derived using a soil-water partitioning equation (Section 4.0). This equation back-calculates from the calculated risk-based groundwater cleanup level. A single set of migration to groundwater criteria apply statewide for Table B1, and are based on conservative assumptions about fate and transport mechanisms in the subsurface, accounting for both (1) release of a contaminant in soil leachate and (2) transport of the contaminant through the underlying soil and aquifer to a receptor well (U.S. EPA. 2012).

---

[1] The atm-m^3/mole units are obtained by multiplying the unitless value by 0.02446 (which comes from multiplying the gas constant (0.0000802 atm-m3/mole-K) by the temperature (298.16 K).

Section 5.0 presents several key equations and factors that support calculations in the proceeding sections, including the approach taken for the dermal absorption route, and derivation of the particulate emission factor, volatilization factor, and other equations.

Equations for the petroleum fraction cleanup values in Table B2 (soil) and Table C (groundwater) are presented in Section 6.0 and, as mentioned above, remain unchanged from the 2008 version of this document. Table B2 petroleum cleanup levels for migration to groundwater are climate-specific, with values established for areas of the state receiving greater than or less than 40 inches of annual precipitation. For all sites with petroleum contamination, the migration to groundwater pathway applies unless the responsible person documents that the pathway is inapplicable, such as in the Arctic zone. Table 1 provides the chemical-specific parameters for the petroleum fractions and Table 2 provides the percentage calculations for combining the aliphatic and aromatic fractions in each range.

Section 7.0 provides procedures for calculating site-specific, method three cleanup levels for the contaminants in both Tables B1 and B2. This includes both the migration-to-groundwater pathway for residential land use scenarios, and also for the commercial/industrial exposure pathways. Tables 3 through 5 list the parameters that can be modified with site-specific data for both Table B1 and B2 compounds.

Table 6 and Table 7 in Appendix A provides the toxicity and chemical-specific parameters for the organic and inorganic chemicals in Table B1 and C. These values are selected from several different references, using the following hierarchy:

- Toxicity
    - EPA's Integrated Risk Information System (IRIS)
    - Professional Peer-Reviewed Toxicity Value (PPRTV)
    - Other toxicity values
        - Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Level (MRLs)
        - California Environmental Protection Agency (Cal EPA) criteria
        - Other sources
- Organic Carbon Partition Coefficient (Koc) (L/kg)
    - Estimation Programs Interface (EPI) Suite estimated values
    - EPA Soil Screening Level (SSL) Exhibit C-1
    - Yaws' Handbook of Thermodynamic and Physical Properties of Chemical Compounds. Knovel, 2003 estimated values
    - EPI Suite experimental values
    - Yaws' Handbook of Thermodynamic and Physical Properties of Chemical Compounds. Knovel, 2003 experimental values
- Dermal Permeability Coefficient (Kp) (cm/hour)
    - EPI Suite estimated values
    - RAGS Part E.
- Effective Predictive Domain (EPD)
    - Calculated based on RAGS Part E criteria for MW and log Kow.
- Fraction Absorbed (FA)
    - RAGS Part E Exhibit B-3; Calculated.

- Molecular Weight (MW) (g/mole)
  - Syracuse Research Corporation (SRC). 2005. PHYSPROP Database. SRC. Syracuse, NY. Accessed July 2005.
  - EPI Suite
  - CRC Handbook of Chemistry and Physics
  - Perry's Chemical Engineers' Handbook (Various Editions).McGraw-Hill
  - Lange's Handbook of Chemistry (Various Editions)
  - Yaws' Handbook of Thermodynamic and Physical Properties of Chemical Compounds
- Water Solubility (S) (mg/L at 25 °C, unless otherwise stated in the source.).
  - SRC PHYSPROP
  - EPI experimental values
  - CRC Handbook of Chemistry and Physics
  - Yaws' Handbook of Thermodynamic and Physical Properties of Chemical Compounds experimental values
  - Perry's Chemical Engineers' Handbook (Various Editions).McGraw-Hill
  - Lange's Handbook of Chemistry (Various Editions)
  - Yaws' Handbook of Thermodynamic and Physical Properties of Chemical Compounds estimated values
  - EPI estimated values
- Unitless Henry's Law Constant (H' at 25 °C, unless otherwise stated in the source.)
  - SRC PHYSPROP
  - EPI experimental values
  - Yaws' Handbook of Thermodynamic and Physical Properties of Chemical Compounds experimental values
  - EPI Suite group-estimated values
  - EPI Suite bond-estimated values
- Henry's Law Constant (atm-m3/mole at 25 °C, unless otherwise stated in the source.)
  - SRC PHYSPROP
  - EPI experimental values
  - Yaws' Handbook of Thermodynamic and Physical Properties of Chemical Compounds experimental values
  - EPI group-estimated values
  - EPI bond-estimated values
- Diffusivity in Air (Dia) (cm2/s)
  - EPA's WATER9 equations.
- Diffusivity in Water (Diw) (cm2/s)
  - EPA's WATER9 equations.
- Soil-Water Partition Coefficient (Kd) (cm3/g).
  - SSL
  - Baes, C.F. 1984. Oak Ridge National Laboratory. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture
- Density (g/cm3)
  - CRC Handbook of Chemistry and Physics
  - Perry's Chemical Engineers' Handbook (Various Editions).McGraw-Hill

    - Lange's Handbook of Chemistry (Various Editions)
    - IRIS.
- Melting Point (MP °C)
    - SRC PHYSPROP
    - EPI experimental values
    - CRC Handbook of Chemistry and Physics
    - Perry's Chemical Engineers' Handbook (Various Editions).McGraw-Hill
    - Lange's Handbook of Chemistry (Various Editions)
    - EPI Suite estimated values
- log Octanol-Water Partition Coefficient (log Kow)
    - EPI experimental values
    - Yaws' Handbook of Thermodynamic and Physical Properties of Chemical Compounds experimental values
    - EPI Suite estimated values
    - Yaws' Handbook of Thermodynamic and Physical Properties of Chemical Compounds estimated values

Table 8 provides the list of Standard Default Parameters used in the equations in this document and calculations via which the Table B1 cleanup levels are derived.

2.0 Groundwater Cleanup Level Equations

2.1 Groundwater Cleanup Level Equation for Non-Carcinogenic Compounds

Cleanup level equations for exposure to non-carcinogenic compounds in groundwater are presented below. The terms used in the equations are defined in Appendix B. The equations include exposure routes via ingestion, dermal contact, and inhalation of volatiles, which are then totaled to produce a final value.

2.1.1 Ingestion of Water

$$CL_{water-nc-ing}(\mu g/L) = \frac{THQ \times AT_{reswc}\left(\frac{365\ days}{year} \times ED_{reswc}(6\ years)\right) \times BW_{reswc}(15\ kg) \times \left(\frac{1000\mu g}{mg}\right)}{EF_{reswc}\left(350\frac{days}{year}\right) \times ED_{reswc}(6\ years) \times \frac{1}{RfD_0\left(\frac{mg}{kg\cdot d}\right)} \times IRW_{reswc}\left(0.78\frac{L}{day}\right)}$$

2.1.2 Dermal for Inorganics

$$CL_{water-nc-der}(\mu g/L) = \frac{DA_{event}\left(\frac{\mu g}{cm^2\cdot event}\right) \times \left(\frac{1000cm^3}{L}\right)}{K_p\left(\frac{cm}{hr}\right) \times ET^{der}_{reswc}\left(0.54\ \frac{hours}{event}\right)}$$

Where:

$$DA_{event}\left(\frac{\mu g}{cm^2 \cdot event}\right) = \frac{THQ \times AT_{reswc}\left(\frac{365\ days}{year} \times ED_{reswc}(6\ years)\right) \times \left(\frac{1000\mu g}{mg}\right) \times BW_{reswc}(15\ kg)}{\left(\frac{1}{RfD_0\left(\frac{mg}{kg\cdot day}\right) \times GIABS}\right) \times EV_{reswc}\left(\frac{1\ events}{day}\right) \times ED_{reswc}(6\ years) \times EF_{reswc}\left(\frac{350\ days}{year}\right) \times SA_{reswc}(6{,}378\ cm^2)}$$

2.1.3 Dermal for Organics

If $ET^{der}_{reswc}\left(0.54\ \frac{hours}{event}\right) \leq t^*(hr)$, then $CL_{water-nc-der}(\mu g/L)$

$$= \frac{DA_{event}\left(\frac{\mu g}{cm^2\cdot event}\right) \times \left(\frac{1000cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hr}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times If\ ET^{der}_{reswc}\left(0.54\ \frac{hours}{event}\right)}{\pi}}}$$

Or,

$$\text{If } ET^{der}_{reswc}\left(0.54\ \frac{hours}{event}\right) > \text{t}^*(\text{hr}), \text{then } \text{CL}_{\text{water-nc-der}}(\mu\text{g/L}) = \frac{\text{DA}_{\text{event}}\left(\frac{\mu\text{g}}{\text{cm}^2\cdot\text{event}}\right)\times\left(\frac{1000\text{cm}^3}{\text{L}}\right)}{\text{FA}\times\text{K}_\text{p}\left(\frac{\text{cm}}{\text{hr}}\right)\left[\frac{ET^{der}_{reswc}\left(0.54\frac{hours}{event}\right)}{1+\text{B}}+2\times\tau_{\text{event}}\left(\frac{\text{hours}}{\text{event}}\right)\times\left(\frac{1+3\text{B}+3\text{B}^2}{(1+\text{B})^2}\right)\right]}$$

2.1.4 Inhalation of Volatiles

$$\text{CL}_{\text{water-nc-inh}}(\mu\text{g/L}) = \frac{\text{THQ}\times\text{AT}_{\text{reswc}}\left(\frac{365\text{ days}}{\text{year}}\times\text{ED}_{\text{reswc}}(6\text{ years})\right)\times\left(\frac{1000\mu\text{g}}{\text{mg}}\right)}{\text{EF}_{\text{reswc}}\left(350\ \frac{\text{days}}{\text{year}}\right)\times\text{ED}_{\text{reswc}}(6\text{ years})\times ET^{inh}_{reswc}\left(\frac{24\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times\frac{1}{\text{RfC}\left(\frac{\text{mg}}{\text{m}^3}\right)}\times\text{K}\ \left(\frac{0.5\text{L}}{\text{m}^3}\right)}$$

2.1.5 Total Non-carcinogenic Risk for All Groundwater Exposure Pathways

$$CL_{res-water-nc-tot}\left(\frac{\mu g}{L}\right) = \frac{1}{\frac{1}{CL_{water-nc-ing}}+\frac{1}{CL_{water-nc-der}}+\frac{1}{CL_{water-nc-inh}}}$$

2.2 Groundwater Cleanup Level Equation for Carcinogenic Compounds

Cleanup level equations for exposure to carcinogenic compounds in groundwater are presented below. The equations include exposure routes via ingestion, dermal contact, and inhalation of volatiles, which are then totaled to produce a final value.

2.2.1 Ingestion of Water

$$CL_{water-ca-ing}(\mu g/L) = \frac{TR\times AT_{resw}\left(\frac{365\ days}{year}\times LT(70\ years)\right)\times\left(\frac{1000\mu g}{mg}\right)}{CSF_0\left(\frac{mg}{kg\cdot day}\right)^{-1}\times\left(IFW_{res-adj}\left(327.95\frac{L}{kg}\right)\right)}$$

Where:

$$IFW_{res-adj}\left(327.95\frac{L}{Kg}\right) = \frac{ED_{reswc}(6\ years)\times EF_{reswc}\left(350\frac{days}{year}\right)\times IRW_{reswc}\left(0.78\frac{L}{day}\right)}{BW_{reswc}(15\ kg)} + \frac{[ED_{resw}(26\ years)-ED_{reswc}(6\ years)]\times EF_{reswa}\left(350\frac{days}{year}\right)\times IRW_{reswa}\left(2.5\frac{L}{day}\right)}{BW_{reswa}(80\ kg)}$$

2.2.2 Dermal for Inorganics

$$CL_{water-ca-der}(\mu g/L) = \frac{DA_{event}\left(\frac{\mu g}{cm^2 \cdot event}\right) \times \left(\frac{1000 cm^3}{L}\right)}{K_p\left(\frac{cm}{hr}\right) \times ET^{der}_{resw-adj}\left(0.67077 \frac{hours}{event}\right)}$$

2.2.3 Dermal for Organics

$$IF\ ET^{der}_{resw-adj}\left(0.67077 \frac{hours}{event}\right) \leq t^*(hr), then\ CL_{water-ca-der}(\mu g/L) = \frac{DA_{event}\left(\frac{\mu g}{cm^2 \cdot event}\right) \times \left(\frac{1000 cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hr}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET^{der}_{resw-adj}\left(0.67077 \frac{hours}{event}\right)}{\pi}}}$$

Or,

$$IF\ ET^{der}_{resw-adj}\left(0.67077 \frac{hours}{event}\right) > t^*(hr), then\ CL_{water-ca-der}(\mu g/L) = \frac{DA_{event}\left(\frac{\mu g}{cm^2 \cdot event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hr}\right) \times \left[\frac{ET_{resw-adj}\left(0.67077 \frac{hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event}\left(\frac{\mu g}{cm^2 \cdot event}\right) = \frac{TR \times AT_{resw}\left(\frac{365\ days}{year} \times LT(70\ years)\right) \times \left(\frac{1000 \mu g}{mg}\right)}{\left(\frac{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1}}{GIABS}\right) \times DFW_{res-adj}\left(2721670 \frac{cm^2 \cdot event}{kg}\right)}$$

$$DFW_{res-adj}\left(2721670 \frac{cm^2 \cdot event}{kg}\right) = \frac{EV_{reswc}\left(\frac{1\ events}{day}\right) \times ED_{reswc}(6\ years) \times EF_{reswc}\left(350 \frac{days}{year}\right) \times SA_{reswc}(6{,}378\ cm^2)}{BW_{reswc}(15\ kg)} + \frac{EV_{reswa}\left(\frac{1\ events}{day}\right) \times ED_{reswa}(20\ years) \times EF_{reswa}\left(350 \frac{days}{year}\right) \times SA_{reswa}(20{,}900\ cm^2)}{BW_{reswa}(80 kg)}$$

And:

$$ET^{der}_{resw-adj}\left(0.67077\frac{hours}{event}\right) = \frac{ET^{der}_{reswc}\left(0.54\frac{hours}{event}\right) \times ED_{reswc}(6\ years) + ET^{der}_{reswa}\left(0.71\frac{hours}{event}\right) \times [ED_{resw}(26\ years) - ED_{reswc}(6\ years)]}{ED_{resw}(26\ years)}$$

2.2.4 Inhalation of Volatiles

$$CL_{water-ca-inh}(\mu g/L) = \frac{TR \times AT_{resw}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}{EF_{resw}\left(\frac{350\ days}{year}\right) \times ED_{resw}(26\ years) \times ET^{inh}_{resw}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times K\left(\frac{0.5L}{m^3}\right)}$$

2.2.5 Total Carcinogenic Risk for All Groundwater Exposure Pathways

$$CL_{water-ca-tot}(\mu g/L) = \frac{1}{\frac{1}{CL_{water-ca-ing}} + \frac{1}{CL_{water-ca-der}} + \frac{1}{CL_{water-ca-inh}}}$$

2.3 Mutagenic Equation for Groundwater

Cleanup level equations for exposure to mutagenic compounds in groundwater are presented below. The equations include exposure routes via ingestion, dermal contact, and inhalation of volatiles, which are then totaled to produce a final value.

2.3.1 Ingestion of Water

$$CL_{water-mu-ing}(\mu g/L) = \frac{TR \times AT_{resw}\left(\frac{365\ days}{year} \times LT(70\ years)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1} \times IFWM_{res-adj}\left(1019.9\frac{L}{kg}\right)}$$

Where:

$$IFWM_{res-adj}\left(1019.9\frac{L}{Kg}\right) = \frac{ED_{0-2}(2\ years) \times EF_{0-2}\left(350\frac{days}{year}\right) \times IRW_{0-2}\left(0.78\frac{L}{day}\right) \times 10}{BW_{0-2}(15\ kg)} + \frac{ED_{2-6}(4\ years) \times EF_{2-6}\left(350\frac{days}{year}\right) \times IRW_{2-6}\left(0.78\frac{L}{day}\right) \times 3}{BW_{2-6}(15\ kg)} + \frac{ED_{6-16}(10\ years) \times EF_{6-16}\left(350\frac{days}{year}\right) \times IRW_{6-16}\left(2.5\frac{L}{day}\right) \times 3}{BW_{6-16}(80\ kg)} + \frac{ED_{16-60}(10\ years) \times EF_{16-30}\left(350\frac{days}{year}\right) \times IRW_{16-30}\left(2.5\frac{L}{day}\right) \times 1}{BW_{16-30}(80\ kg)}$$

2.3.2 Dermal

2.3.2.1 Dermal for Inorganics:

$$CL_{water-mu-der}(\mu g/L) = \frac{DA_{event}\left(\frac{\mu g}{cm^2 \cdot event}\right) \times \left(\frac{1000cm^3}{L}\right)}{K_p\left(\frac{cm}{hr}\right) \times ET_{resw-madj}\left(0.67077\frac{hours}{event}\right)}$$

2.3.2.2 Dermal for Organics:

$$IF\ ET_{resw-madj}\left(0.67077\frac{hours}{event}\right) \leq t^*(hr), then\ CL_{water-mu-der}(\mu g/L) = \frac{DA_{event}\left(\frac{\mu g}{cm^2 \cdot event}\right) \times \left(\frac{1000cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hr}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET_{resw-madj}\left(0.67077\frac{hours}{event}\right)}{\pi}}}$$

Or

$$IF\ ET_{resw-madj}\left(0.67077\frac{hours}{event}\right) > t^*(hr), then\ CL_{water-mu-der}(\mu g/L) = \frac{DA_{event}\left(\frac{\mu g}{cm^2 \cdot event}\right) \times \left(\frac{1000cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hr}\right) \times \left[\frac{ET_{resw-madj}\left(0.67077\frac{hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event}\left(\frac{\mu g}{cm^2 \cdot event}\right) = \frac{TR \times AT_{resw}\left(\frac{365\ days}{year} \times LT(70\ years)\right) \times \left(\frac{1000 \mu g}{mg}\right)}{\left(\frac{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1}}{GIABS}\right) \times DFWM_{res-adj}\left(8419740 \frac{events \cdot cm^2}{kg}\right)}$$

Where:

$$DFWM_{res-adj}\left(8419740 \frac{events \cdot cm^2}{kg}\right) = \left[\left(\frac{EV_{0-2}\left(\frac{1\ events}{day}\right) \times ED_{0-2}(2\ years) \times EF_{0-2}\left(350 \frac{days}{year}\right) \times SA_{0-2}(6{,}378\ cm^2) \times 10}{BW_{0-2}(15\ kg)}\right) + \left(\frac{EV_{2-6}\left(\frac{1\ events}{day}\right) \times ED_{2-6}(4\ years) \times EF_{2-6}\left(350 \frac{days}{year}\right) \times SA_{2-6}(6{,}378\ cm^2) \times 3}{BW_{2-6}(15\ kg)}\right) + \left(\frac{EV_{6-16}\left(\frac{1\ events}{day}\right) \times ED_{6-16}(10\ years) \times EF_{6-16}\left(350 \frac{days}{year}\right) \times SA_{6-16}(20{,}900\ cm^2) \times 3}{BW_{6-16}(80\ kg)}\right) + \left(\frac{EV_{16-26}\left(\frac{1\ events}{day}\right) \times ED_{16-26}(10\ years) \times EF_{16-26}\left(350 \frac{days}{year}\right) \times SA_{16-26}(20{,}900\ cm^2) \times 1}{BW_{16-26}(80\ kg)}\right)\right]$$

And:

$$ET_{resw-madj}\left(0.67077 \frac{hours}{event}\right) = \frac{\begin{pmatrix} ET_{0-2}^{der}\left(0.54 \frac{hours}{event}\right) \times ED_{0-2}(2\ years) + ET_{2-6}^{der}\left(0.54 \frac{hour}{event}\right) \times ED_{2-6}(4\ years) \\ +ET_{6-16}^{der}\left(0.71 \frac{hours}{event}\right) \times ED_{6-16}(10\ years) + ET_{16-26}^{der}\left(0.71 \frac{hours}{event}\right) \times ED_{16-30}(10\ years) \end{pmatrix}}{ED_{0-2}(2\ years) + ED_{2-6}(4\ years) + ED_{6-16}(10\ years) + ED_{16-26}(10\ years)}$$

2.3.3 Inhalation of Volatiles

$$CL_{water-mu-inh}(\mu g/L) = \frac{TR \times AT_{resw}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}{K\left(\frac{0.5L}{m^3}\right) \times ET_{resw}^{inh}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \left[\begin{pmatrix} \left(ED_{0-2}(years) \times EF_{0-2}\left(350\ \frac{days}{year}\right) \times IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times 10\right) + \left(ED_{2-6}(years) \times EF_{2-6}\left(350\ \frac{days}{year}\right) \times IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times 3\right) + \\ \left(ED_{6-16}(years) \times EF_{6-10}\left(350\ \frac{days}{year}\right) \times IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times 3\right) + \left(ED_{16-26}(years) \times EF_{16-26}\left(350\ \frac{days}{year}\right) \times IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times 1\right) \end{pmatrix}\right]}$$

2.3.4 Total Mutagenic Risk for All Groundwater Exposure Pathways

$$CL_{water-mu-tot}(\mu g/L) = \frac{1}{\frac{1}{CL_{water-mu-ing}} + \frac{1}{CL_{water-mu-der}} + \frac{1}{CL_{water-mu-inh}}}$$

2.4 Vinyl Chloride

2.4.1 Ingestion of Water

$$CL_{water-vc-ing}(\mu g/L) = \frac{TR}{\frac{CSF_0\left(\frac{mg}{kg\cdot day}\right)^{-1} \times IFW_{res-adj}\left(327.95\frac{L}{kg}\right) \times \frac{mg}{1000\mu g}}{AT_{resw}\left(\frac{365\ days}{year} \times LT(70\ years)\right)} + \frac{CSF_0\left(\frac{mg}{kg\cdot day}\right)^{-1} \times IRW_{reswc}\left(0.78\frac{L}{day}\right) \times \frac{mg}{1000\mu g}}{BW_{reswc}(15\text{kg})}}$$

Where:

$$IFW_{res-adj}\left(327.95\frac{L}{kg}\right) = \frac{ED_{reswc}(6\ years) \times EF_{reswc}\left(350\frac{days}{year}\right) \times IRW_{reswc}\left(0.78\frac{L}{day}\right)}{BW_{reswc}(15\ Kg)} + \frac{[ED_{resw}(26\ years) - ED_{reswc}(6\ years)] \times EF_{reswa}\left(350\frac{days}{year}\right) \times IRW_{reswa}\left(2.5\frac{L}{day}\right)}{BW_{reswa}(80\ kg)}$$

2.4.2 Dermal

$$IF\ ET^{der}_{resw-adj}\left(0.67077\frac{hours}{event}\right) \le t^*(hr), then\ CL_{water-vc-der}(\mu g/L) = \frac{DA_{event}\left(\frac{\mu g}{cm^2\cdot event}\right) \times \left(\frac{1000cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hr}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET^{der}_{resw-adj}\left(0.67077\frac{hours}{event}\right)}{\pi}}}$$

Or,

$$IF\ ET^{der}_{resw-adj}\left(0.67077\frac{hours}{event}\right) > t^{*}(hr), then\ CL_{water-vc-der}(\mu g/L)$$
$$= \frac{DA_{event}\left(\frac{\mu g}{cm^2 \cdot event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hr}\right) \times \left[\frac{ET^{der}_{resw-adj}\left(0.67077\frac{hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event}\left(\frac{\mu g}{cm^2 \cdot event}\right) = \frac{TR}{\left(\frac{\left(\frac{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1}}{GIABS}\right) \times DFW_{res-adj}\left(2721670\frac{cm^2 \cdot event}{kg}\right)}{AT_{resw}\left(\frac{365\ days}{year} \times \text{LT(70 years)}\right) \times \frac{1000\ \mu g}{mg}}\right) + \left(\frac{\left(\frac{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1}}{GIABS}\right) \times EV_{reswc}\left(\frac{1\ event}{day}\right) \times SA_{reswc}(6378\ cm^2)}{BW_{reswc}(15kg) \times \frac{1000\ \mu g}{mg}}\right)}$$

Where:

$$DFW_{res-adj}\left(2721670\frac{cm^2 \cdot event}{kg}\right) = \frac{EV_{reswc}\left(\frac{1\ events}{day}\right) \times ED_{reswc}(6\ years) \times EF_{reswc}\left(350\frac{days}{year}\right) \times SA_{reswc}(6{,}378\ cm^2)}{BW_{reswc}(15\ kg)} + \frac{EV_{reswa}\left(\frac{1\ events}{day}\right) \times ED_{reswa}(24\ years) \times EF_{reswa}\left(350\frac{days}{year}\right) \times SA_{reswa}(20{,}900\ cm^2)}{BW_{reswa}(80kg)}$$

And:

$$ET^{der}_{resw-adj}\left(0.67077\frac{hours}{event}\right) = \frac{ET^{der}_{reswc}\left(0.54\frac{hours}{event}\right) \times ED_{reswc}(6\ years) + ET^{der}_{reswa}\left(0.71\frac{hours}{event}\right) \times [ED_{resw}(26\ years) - ED_{reswc}(6\ years)]}{ED_{resw}(26\ years)}$$

2.4.3 Inhalation

$$CL_{water-vc-inh}(\mu g/L) = \frac{TR}{\left(\frac{IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times EF_{resw}\left(\frac{350\ days}{year}\right) \times ED_{resw}(26\ years) \times ET^{inh}_{resw}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times K\left(\frac{0.5L}{m^3}\right)}{AT_{resw}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}\right) + \left(IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times K\left(\frac{0.5L}{m^3}\right)\right)}$$

2.4.4 Total

$$CL_{water-vc-tot}(mg/kg) = \frac{1}{\frac{1}{CL_{water-vc-ing}} + \frac{1}{CL_{water-vc-der}} + \frac{1}{CL_{water-vc-inh}}}$$

2.5 Trichloroethylene

2.5.1 Ingestion of Water

$$CL_{water-tce-ing}(\mu g/L) = \frac{TR \times AT_{resw}\left(\frac{365\ days}{year} \times LT(70\ years)\right) \times \frac{(1000 \mu g)}{mg}}{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1} \times \left[\left(CAF_0(0.804) \times IFW_{resw-adj}\left(327.95 \frac{L}{kg}\right)\right) + \left(MAF_0(0.202) \times IFWM_{res-adj}\left(1019.9 \frac{L}{kg}\right)\right)\right]}$$

Where:

$$CAF_O(0.804) = \frac{CSF_O\left(0.037 \frac{mg}{kg \cdot day}\right)^{-1}\ NHL + Liver\ Oral\ Slope\ Factor}{CSF_O\left(0.046 \frac{mg}{kg \cdot day}\right)^{-1}\ Adult - Based\ Oral\ Slope\ Factor}$$

$$MAF_O(0.202) = \frac{CSF_O\left(0.0093 \frac{mg}{kg \cdot day}\right)^{-1}\ Kidney\ Oral\ Slope\ Factor}{CSF_O\left(0.046 \frac{mg}{kg \cdot day}\right)^{-1}\ Adult - Based\ Oral\ Slope\ Factor}$$

$$IFW_{res-adj}\left(327.95 \frac{L}{kg}\right) = \frac{ED_{reswc}(6\ years) \times EF_{reswc}\left(350 \frac{days}{year}\right) \times IRW_{reswc}\left(0.78 \frac{L}{day}\right)}{BW_{reswc}(15\ kg)} + \frac{[ED_{resw}(26\ years) - ED_{reswc}(6\ years)] \times EF_{reswa}\left(350 \frac{days}{year}\right) \times IRW_{reswa}\left(2.5 \frac{L}{day}\right)}{BW_{reswa}(80\ kg)}$$

$$IFWM_{res-adj}\left(1019.9 \frac{L}{Kg}\right) = \frac{ED_{0-2}(2\ years) \times EF_{0-2}\left(350 \frac{days}{year}\right) \times IRW_{0-2}\left(0.78 \frac{L}{day}\right) \times 10}{BW_{0-2}(15\ kg)} + \frac{ED_{2-6}(4\ years) \times EF_{2-6}\left(350 \frac{days}{year}\right) \times IRW_{2-6}\left(0.78 \frac{L}{day}\right) \times 3}{BW_{2-6}(15\ kg)} + \frac{ED_{6-16}(10\ years) \times EF_{6-16}\left(350 \frac{days}{year}\right) \times IRW_{6-16}\left(2.5 \frac{L}{day}\right) \times 3}{BW_{6-16}(80\ kg)} + \frac{ED_{16-26}(10\ years) \times EF_{16-26}\left(350 \frac{days}{year}\right) \times IRW_{16-26}\left(2.5 \frac{L}{day}\right) \times 1}{BW_{16-26}(80\ kg)}$$

2.5.2 Dermal

$$IF\ ET^{der}_{resw-adj}\left(0.67077\frac{hours}{event}\right) \le t^{*}(hr), then\ CL_{water-tce-der}(\mu g/L)$$

$$= \frac{DA_{tce-event}\left(\frac{\mu g}{cm^2 \cdot event}\right) \times \left(\frac{1000 cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hr}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET^{der}_{resw-adj}\left(0.67077\frac{hours}{event}\right)}{\pi}}}$$

Or,

$$IF\ ET^{der}_{resw-adj}\left(0.67077\frac{hours}{event}\right) > t^{*}(hr), then\ CL_{water-tce-der}(\mu g/L)$$

$$= \frac{DA_{tce-event}\left(\frac{\mu g}{cm^2 \cdot event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hr}\right) \times \left[\frac{ET^{der}_{resw-adj}\left(0.67077\frac{hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{tce-event}\left(\frac{\mu g}{cm^2 \cdot event}\right)$$

$$= \frac{TR \times AT_{resw}\left(\frac{365\ days}{year} \times LT(70\ years)\right) \times \left(\frac{1000 \mu g}{mg}\right)}{\left(\frac{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1}}{GIABS}\right) \times \left[\left(CAF_0(0.804) \times DFW_{resw-adj}\left(2721670\frac{events \cdot cm^2}{kg}\right)\right) + \left(MAF_0(0.202) \times DFWM_{res-adj}\left(8419740\frac{events \cdot cm^2}{kg}\right)\right)\right]}$$

Where:

$$DFW_{res-adj}\left(2721670\frac{cm^2 \cdot event}{kg}\right)$$

$$= \frac{EV_{reswc}\left(\frac{1\ events}{day}\right) \times ED_{reswc}(6\ years) \times EF_{reswc}\left(350\frac{days}{year}\right) \times SA_{reswc}(6{,}378\ cm^2)}{BW_{reswc}(15\ kg)} + \frac{EV_{reswa}\left(\frac{1\ events}{day}\right) \times ED_{reswa}(20\ years) \times EF_{reswa}\left(350\frac{days}{year}\right) \times SA_{reswa}(20{,}900\ cm^2)}{BW_{reswa}(80 kg)}$$

And:

$$DFWM_{res-adj}\left(8419740\frac{events\cdot cm^2}{kg}\right)$$
$$=\left[\left(\frac{EV_{0-2}\left(\frac{1\ events}{day}\right)\times ED_{0-2}(2\ years)\times EF_{0-2}\left(350\frac{days}{year}\right)\times SA_{0-2}(6{,}378\ cm^2)\times 10}{BW_{0-2}(15\ kg)}\right)\right.$$
$$+\left(\frac{EV_{2-6}\left(\frac{1\ events}{day}\right)\times ED_{2-6}(4\ years)\times EF_{2-6}\left(350\frac{days}{year}\right)\times SA_{2-6}(6{,}378\ cm^2)\times 3}{BW_{2-6}(15\ kg)}\right)$$
$$+\left(\frac{EV_{6-16}\left(\frac{1\ events}{day}\right)\times ED_{6-16}(10\ years)\times EF_{6-16}\left(350\frac{days}{year}\right)\times SA_{6-16}(20{,}900\ cm^2)\times 3}{BW_{6-16}(80\ kg)}\right)$$
$$\left.+\left(\frac{EV_{16-30}\left(\frac{1\ events}{day}\right)\times ED_{16-26}(10\ years)\times EF_{16-26}\left(350\frac{days}{year}\right)\times SA_{16-26}(20{,}900\ cm^2)\times 1}{BW_{16-26}(80\ kg)}\right)\right]$$

And:

$$ET^{der}_{resw-madj}\left(0.67077\frac{hours}{event}\right)$$
$$=\frac{\begin{array}{c}ET^{der}_{0-2}\left(0.54\frac{hours}{event}\right)\times ED_{0-2}(2\ years)+ET^{der}_{2-6}\left(0.54\frac{hours}{event}\right)\times ED_{2-6}(4\ years)\\ +ET^{der}_{6-16}\left(0.71\frac{hours}{event}\right)\times ED_{6-16}(10\ years)+ET^{der}_{16-26}\left(0.71\frac{hours}{event}\right)\times ED_{16-26}(10\ years)\end{array}}{ED_{0-2}(2\ years)+ED_{2-6}(4\ years)+ED_{6-16}(10\ years)+ED_{16-26}(10\ years)}$$

2.5.3 Inhalation

$$CL_{water-tce-inh}\left(\frac{\mu g}{L}\right)$$
$$=\frac{TR\times AT_{resw}\left(\frac{365\ days}{year}\times \mathrm{LT}(70\ years)\right)}{ET^{inh}_{resw}\left(\frac{24\ hours}{day}\right)\times\frac{1\ day}{24\ hours}\times \mathrm{K}\left(0.5\frac{L}{m^3}\right)\times \mathrm{IUR}\left(\frac{\mu g}{m^3}\right)^{-1}}$$
$$\times\left[\begin{array}{c}\left(EF_{resw}\left(350\frac{days}{year}\right)\times ED_{resw}(26\ years)\times CAF_i(0.756)\right)+\left(ED_{0-2}(2\ years)\times EF_{0-2}\left(350\frac{days}{year}\right)\times MAF_i(0.244)\times 10\right)\\ +\left(ED_{2-6}(4\ years)\times EF_{2-6}\left(350\frac{days}{year}\right)\times MAF_i(0.244)\times 3\right)+\left(ED_{6-16}(10\ years)\times EF_{6-16}\left(350\frac{days}{year}\right)\times MAF_i(0.244)\times 3\right)\\ +\left(ED_{16-26}(10\ years)\times EF_{16-26}\left(350\frac{days}{year}\right)\times MAF_i(0.244)\times 1\right)\end{array}\right]$$

$$CAF_i(0.756)=\frac{IUR\left(3.1\times 10^{-6}\left(\frac{\mu g}{m^3}\right)^{-1}\right)\ NHL+Liver\ Unit\ Risk\ Estimate}{IUR\left(4.1\times 10^{-6}\left(\frac{\mu g}{m^3}\right)^{-1}\right)\ Adult-Based\ Unit\ Risk\ Estimate}$$

$$MAF_i(0.244)=\frac{IUR\left(1\times 10^{-6}\left(\frac{\mu g}{m^3}\right)^{-1}\right)\ Kidney\ Unit\ Risk\ Estimate}{IUR\left(4.1\times 10^{-6}\left(\frac{\mu g}{m^3}\right)^{-1}\right)\ Adult-Based\ Unit\ Risk\ Estimate}$$

2.5.4 Total

$$CL_{water-tce-tot}(\mu g/L) = \frac{1}{\frac{1}{CL_{water-tce-ing}} + \frac{1}{CL_{water-tce-der}} + \frac{1}{CL_{water-tce-inh}}}$$

3.0 Soil Cleanup Level Equations for Residential Soil

3.1 Equations for Non-Carcinogenic Compounds

Cleanup level equations for exposure to non-carcinogenic compounds in soil are presented below. The terms used in the equations are defined in Appendix B. The equations include exposure routes via ingestion, inhalation of particulates, and dermal contact, which are then totaled to produce a final value.

3.1.1 Incidental Ingestion of Soil

$$CL_{soil-nc-ing}(mg/kg) = \frac{THQ \times AT_{ressc}\left(\frac{365\ days}{year} \times ED_{ressc}(6\ years)\right) \times BW_{ressc}(15\ kg)}{EF_{ressc}\left(\frac{days}{year}\right) \times ED_{ressc}(6\ year) \times \frac{\text{RBA}}{RfD_0\left(\frac{mg}{kg \cdot day}\right)} \times IRS_{ressc}\left(200\frac{mg}{day}\right) \times \frac{10^{-6}kg}{mg}}$$

3.1.2 Dermal Contact with Soil

$$CL_{soil-nc-der}(mg/kg) = \frac{THQ \times AT_{ressc}\left(\frac{365\ days}{year} \times ED_{ressc}(6\ years)\right) \times BW_{ressc}(15\ kg)}{EF_{ress}\left(\frac{days}{year}\right) \times ED_{ressc}(6\ year) \times \frac{1}{\left(RfD_0\left(\frac{mg}{kg \cdot day}\right) \times GIABS\right)} \times SA_{ressc}\left(2373\frac{cm^2}{day}\right) \times AF_{ressc}\left(0.2\frac{mg}{cm^2}\right) \times ABS_d \times \frac{10^{-6}kg}{mg}}$$

3.1.3 Inhalation of Particulates Emitted from Soil

$$CL_{soil-nc-inh}(mg/kg) = \frac{THQ \times AT_{ressc}\left(\frac{365\ days}{year} \times ED_{ressc}(6\ years)\right)}{EF_{ressc}\left(\frac{days}{year}\right) \times ED_{ressc}(6\ year) \times ET_{ressc}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \frac{1}{RfC\left(\frac{mg}{m^3}\right)} \times \left(\frac{1}{VF_s\left(\frac{m^3}{Kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{Kg}\right)}\right)}$$

3.1.4 Total Non-carcinogenic Risk for All Soil Exposure Pathways

$$CL_{soil-nc-tot}(mg/kg) = \frac{1}{\frac{1}{CL_{soil-nc-ing}} + \frac{1}{CL_{soil-nc-der}} + \frac{1}{CL_{soil-nc-inh}}}$$

3.2 Equations for Carcinogenic Compounds

Cleanup level equations for exposure to carcinogenic compounds in soil are presented below. The equations include exposure routes via ingestion, inhalation of particulates, and dermal contact, which are then totaled to produce a final value.

3.2.1 Incidental Ingestion of Soil

$$CL_{soil-ca-ing}(mg/kg) = \frac{TR \times AT_{ress}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1} \times \text{RBA} \times IFS_{res-adj}\left(28350\frac{mg}{kg}\right) \times \left(\frac{10^{-6}kg}{mg}\right)}$$

Where:

$$IFS_{res-adj}\left(28350\frac{mg}{kg}\right) = \frac{ED_{ressc}(6\ years) \times EF_{ressc}\left(\frac{days}{year}\right) \times IRS_{ressc}\left(\frac{200\ mg}{day}\right)}{BW_{ressc}(15\ kg)} + \frac{[ED_{ress}(26\ years) - ED_{ressc}(6\ years)] \times EF_{ressa}\left(\frac{days}{year}\right) \times IRS_{ressa}\left(\frac{100\ mg}{day}\right)}{BW_{ressa}(80\ kg)}$$

3.2.2 Dermal Contact with Soil

$$CL_{res-sol-ca-der}(mg/kg) = \frac{TR \times AT_{ress}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}{\left(\frac{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1}}{GIABS}\right) \times DFS_{res-adj}\left(79758\frac{mg}{kg}\right) \times ABS_d \times \left(\frac{10^{-6}kg}{mg}\right)}$$

Where:

$$DFS_{res-adj}\left(79758\frac{mg}{kg}\right) = \frac{ED_{ressc}(6\ years) \times EF_{ressc}\left(\frac{days}{year}\right) \times SA_{ressc}\left(2373\frac{cm^2}{day}\right) \times AF_{ressc}\left(0.2\frac{mg}{cm^2}\right)}{BW_{ressc}(15\ kg)} + \frac{[ED_{ress}(26\ years) - ED_{ressc}(6\ years)] \times EF_{ressa}\left(\frac{days}{year}\right) \times SA_{ressa}\left(6032\frac{cm^2}{day}\right) \times AF_{ressa}\left(0.07\frac{mg}{cm^2}\right)}{BW_{ressa}(80\ kg)}$$

3.2.3 Inhalation of Particulates Emitted from Soil

$$CL_{soil-ca-inh}(mg/kg) = \frac{TR \times AT_{ress}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}{IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times \left(\frac{1000\ \mu g}{mg}\right) \times EF_{ress}\left(\frac{days}{year}\right) \times \left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right) \times ED_{ress}(26\ year) \times ET_{ress}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right)}$$

3.2.4 Total Carcinogenic Risk for All Soil Exposure Pathways

$$CL_{soil-ca-tot}(mg/kg) = \frac{1}{\frac{1}{CL_{soil-ca-ing}} + \frac{1}{CL_{soil-ca-der}} + \frac{1}{CL_{soil-ca-inh}}}$$

3.3 Equations for Mutagenic Compounds

Cleanup level equations for exposure to mutagenic compounds in soil are presented below. For these compounds, the exposure rates take into account age-specific susceptibility to mutagens through the use of an age dependent adjustment factor (ADAF). The equations include exposure routes via ingestion, inhalation of particulates, and dermal contact, which are then totaled to produce a final value.

3.3.1 Incidental Ingestion of Soil

$$CL_{soil-mu-ing}(mg/kg) = \frac{TR \times AT_{ress}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1} \times RBA \times IFSM_{res-adj}\left(128700\frac{mg}{kg}\right) \times \left(\frac{10^{-6}kg}{mg}\right)}$$

Where:

$$IFSM_{res-adj}\left(128700\frac{mg}{kg}\right) = \frac{ED_{0-2}(2\ years) \times EF_{0-2}\left(\frac{days}{year}\right) \times IRS_{0-2}\left(200\frac{mg}{day}\right) \times 10}{BW_{0-2}(15\ kg)} + \frac{ED_{2-6}(4\ years) \times EF_{2-6}\left(\frac{days}{year}\right) \times IRS_{2-6}\left(200\frac{mg}{day}\right) \times 3}{BW_{2-6}(15\ kg)} + \frac{ED_{6-16}(10\ years) \times EF_{6-16}\left(\frac{days}{year}\right) \times IRS_{6-16}\left(100\frac{mg}{day}\right) \times 3}{BW_{6-16}(80\ kg)} + \frac{ED_{16-26}(10\ years) \times EF_{16-26}\left(\frac{days}{year}\right) \times IRS_{16-26}\left(100\frac{mg}{day}\right) \times 1}{BW_{16-26}(80\ kg)}$$

3.3.2 Dermal Contact with Soil

$$CL_{soil-mu-der}(mg/kg) = \frac{TR \times AT_{ress}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}{\left(\frac{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1}}{GIABS}\right) \times DFSM_{res-adj}\left(330372\frac{mg}{kg}\right) \times ABS_d \times \left(\frac{10^{-6}kg}{mg}\right)}$$

Where:

$$DFSM_{res-adj}\left(330372\frac{mg}{kg}\right) = \frac{ED_{0-2}(2\ years) \times EF_{0-2}\left(\frac{days}{year}\right) \times AF_{0-2}\left(0.2\frac{mg}{cm^2}\right) \times SA_{0-2}\left(2373\frac{cm^2}{day}\right) \times 10}{BW_{0-2}(15\ kg)} + \frac{ED_{2-6}(4\ years) \times EF_{2-6}\left(\frac{days}{year}\right) \times AF_{2-6}\left(0.2\frac{mg}{cm^2}\right) \times SA_{2-6}\left(2373\frac{cm^2}{day}\right) \times 3}{BW_{2-6}(15\ kg)} + \frac{ED_{6-16}(10\ years) \times EF_{6-16}\left(\frac{days}{year}\right) \times AF_{6-16}\left(0.07\frac{mg}{cm^2}\right) \times SA_{6-16}\left(6032\frac{cm^2}{day}\right) \times 3}{BW_{6-16}(80\ kg)} + \frac{ED_{16-26}(10\ years) \times EF_{16-26}\left(\frac{days}{year}\right) \times AF_{16-26}\left(0.07\frac{mg}{cm^2}\right) \times SA_{16-26}\left(6032\frac{cm^2}{day}\right) \times 1}{BW_{16-26}(80\ kg)}$$

3.3.3 Inhalation of Particulates Emitted from Soil

$$CL_{soil-mu-inh}(mg/kg) = \frac{TR \times AT_{ress}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}{IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times \left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times \left(\begin{array}{l}\left(ED_{0-2}(2\ years) \times EF_{0-2}\left(\frac{days}{year}\right) \times ET_{0-2}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times 10\right) + \left(ED_{2-6}(4\ years) \times EF_{2-6}\left(\frac{days}{year}\right) \times ET_{2-6}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times 3\right) + \\ \left(ED_{6-16}(10\ years) \times EF_{6-16}\left(\frac{days}{year}\right) \times ET_{6-16}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times 3\right) + \left(ED_{16-26}(10\ years) \times EF_{16-26}\left(\frac{days}{year}\right) \times ET_{6-16}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times 1\right)\end{array}\right)}$$

3.3.4 Total Mutagenic Risk for All Soil Exposure Pathways

$$CL_{soil-mu-tot}(mg/kg) = \frac{1}{\frac{1}{CL_{soil-mu-ing}} + \frac{1}{CL_{soil-mu-der}} + \frac{1}{CL_{soil-mu-inh}}}$$

3.4 Equations for Vinyl Chloride

Cleanup level equations for exposure to vinyl chloride in soil are presented below. The equations include exposure routes via ingestion, inhalation of particulates, and dermal contact, which are then totaled to produce a final value.

3.4.1 Incidental Ingestion of Soil

$$CL_{soil-vc-ing}\left(\frac{mg}{kg}\right) = \frac{TR}{\left(\frac{CSF_0\left(\frac{mg}{kg\cdot day}\right)^{-1} \times \text{RBA} \times IFS_{res-adj}\left(28350\frac{mg}{kg}\right) \times \frac{10^{-6}kg}{mg}}{AT_{ress}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}\right) + \left(\frac{CSF_0\left(\frac{mg}{kg\cdot day}\right)^{-1} \times \text{RBA} \times IRS_{ressc}\left(200\frac{mg}{day}\right) \times \frac{10^{-6}kg}{mg}}{BW_{ressc}(15\ kg)}\right)}$$

Where $IFS_{res\text{-}adj}$ = $IFS_{res\text{-}adj}$ from Section 3.2.1

3.4.2 Dermal Contact with Soil

$$CL_{soil-vc-der}\left(\frac{mg}{kg}\right) = \frac{TR}{\left(\frac{\frac{CSF_0\left(\frac{mg}{kg\cdot day}\right)^{-1}}{GIABS} \times DFS_{res-adj}\left(79758\frac{mg}{kg}\right) \times ABS_d \times \frac{10^{-6}kg}{mg}}{AT_{ress}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}\right) + \left(\frac{\frac{CSF_0\left(\frac{mg}{kg\cdot day}\right)^{-1}}{GIABS} \times SA_{ressc}\left(2373\frac{cm^2}{day}\right) \times AF_{ressc}\left(0.2\frac{mg}{cm^2}\right) \times ABS \times \frac{10^{-6}kg}{mg}}{BW_{ressc}(15\ kg)}\right)}$$

Where $DFS_{res\text{-}adj}$ = $DFS_{res\text{-}adj}$ from 3.2.2

3.4.3 Inhalation of Particulates Emitted from Soil

$$CL_{soil-vc-inh}\left(\frac{mg}{kg}\right) = \frac{TR}{\left(\frac{IUR\left(\frac{\mu g}{m^3}\right)^{-1} \times EF_{ress}\left(\frac{days}{year}\right) \times ED_{ress}(26\ years) \times ET_{ress}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{AT_{ress}\left(\frac{365\ days}{year} \times LT(70\ years)\right) \times VF_s\left(\frac{m^3}{kg}\right)}\right) + \left(\frac{IUR\left(\frac{\mu g}{m^3}\right)^{-1}}{VF_s\left(\frac{m^3}{kg}\right)} \times \left(\frac{1000\ \mu g}{mg}\right)\right)}$$

3.4.4 Total Vinyl Chloride Risk for All Soil Exposure Pathways

$$CL_{soil-vc-tot}(mg/kg) = \frac{1}{\frac{1}{CL_{soil-vc-ing}} + \frac{1}{CL_{soil-vc-der}} + \frac{1}{CL_{soil-vc-inh}}}$$

3.5 Trichloroethylene

3.5.1 Ingestion

$$CL_{soil-tce-ing}(mg/kg) = \frac{TR \times AT_{ress}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1} \times \text{RBA} \times \frac{10^{-6} kg}{mg} \times \left[\begin{array}{l}\left(CAF_O(0.804) \times IFS_{res-adj}\left(28350\frac{mg}{kg}\right)\right) \\ +MAF_O(0.202) \times IFSM_{res-adj}\left(128700\frac{mg}{kg}\right)\end{array}\right]}$$

Where:

CAF_O = CAF_O from Section 2.5.1

MAF_O = MAF_O from Section 2.5.1

$IFS_{res\text{-}adj}$ = $IFS_{res\text{-}adj}$ from Section 3.2.1

$IFSM_{res\text{-}adj}$ = $IFSM_{res\text{-}adj}$ from Section 3.3.1

3.5.2 Dermal

$$CL_{soil-\text{tce}-der}\left(\frac{mg}{kg}\right) = \frac{TR \times AT_{ress}\left(\frac{365\ days}{year} \times LT(70\ years)\right)}{\left(\frac{CSF_0\left(\frac{mg}{kg \cdot day}\right)^{-1}}{GIABS}\right) \times \frac{10^{-6} kg}{mg}\left[\begin{array}{l}\left(CAF_O(0.804) \times DFS_{res-adj}\left(79758\frac{mg}{kg}\right) \times ABS_d\right) \\ +\left(MAF_O(0.202) \times DFSM_{res-adj}\left(330372\frac{mg}{kg}\right) \times ABS_d\right)\end{array}\right]}$$

Where:

$DFS_{res\text{-}adj}$ = $DFS_{res\text{-}adj}$ from Section 3.2.2

$DFSM_{res\text{-}adj}$ = $DFSM_{res\text{-}adj}$ from Section 3.3.2

3.5.3 Inhalation

$$CL_{water-tce-inh}\left(\frac{\mu g}{L}\right) = \frac{TR \times AT_{ress}\left(\frac{365\ days}{year} \times \text{LT}(70\ years)\right)}{\text{IUR}\left(\frac{\mu g}{m^3}\right)^{-1} \times \left(\frac{1}{VF_S\left(\frac{m^3}{kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right) \times \frac{1000\ \mu g}{mg} \times \frac{day}{24\ hours}}$$

$$\times \left[\begin{array}{l}\left(EF_{ress}\left(\frac{days}{year}\right) \times ED_{ress}(26\ years) \times ET_{ress}\left(\frac{24\ hours}{day}\right) \times CAF_i(0.756)\right) \\ +\left(ED_{0-2}(2\ years) \times EF_{0-2}\left(\frac{days}{year}\right) \times ET_{0-2}\left(\frac{24\ hours}{day}\right) \times MAF_i(0.244) \times 10\right) \\ +\left(ED_{2-6}(4\ years) \times EF_{2-6}\left(\frac{days}{year}\right) \times ET_{2-6}\left(\frac{24\ hours}{day}\right) \times MAF_i(0.244) \times 3\right) \\ +\left(ED_{6-16}(10\ years) \times EF_{6-16}\left(\frac{days}{year}\right) \times ET_{6-16}\left(\frac{24\ hours}{day}\right) \times MAF_i(0.244) \times 3\right) \\ +\left(ED_{16-26}(10\ years) \times EF_{16-26}\left(\frac{days}{year}\right) \times ET_{16-26}\left(\frac{24\ hours}{day}\right) \times MAF_i(0.244) \times 1\right)\end{array}\right]$$

3.5.4 Total

$$CL_{soil-tce-tot}(mg/kg) = \frac{1}{\frac{1}{CL_{soil-tce-ing}} + \frac{1}{CL_{soil-tce-der}} + \frac{1}{CL_{soil-tce-inh}}}$$

4.0 Migration to Groundwater Cleanup Levels

4.1 Soil-Water Partitioning Equation for Migration to Groundwater

The standard default attenuation factor (AF) used to determine the cleanup standards is: AF = 4. The AF may be modified on a chemical-specific basis. The standard dilution factor is DF = 3.3 (see equation below). The standard default dilution attenuation factor (DAF) used to determine the cleanup standards is: DAF (DF x AF) = 13.2. The standard default value for fractional organic carbon (foc) is 0.001 (0.1%). Exhibit C- 4 of the Soil Screening Guidance (U.S. EPA. 1996a) provides pH-specific soil-water partition coefficients (Kd) for metals. Site-specific soil pH measurements can be used to select appropriate Kd values for these metals. Where site-specific soil pH values are not available, values corresponding to a pH of 6.8 should be used. The soil-water partitioning equation is shown below:

$$CL\ (mg/kg) = C_w\left(\frac{mg}{L}\right) \times DAF \times \left[K_d\left(\frac{L}{kg}\right) + \left(\frac{\left(\theta_w\left(\frac{L_{water}}{L_{soil}}\right) + \theta_a\left(\frac{L_{air}}{L_{soil}}\right) \times H'\right)}{P_b\left(\frac{1.5kg}{L}\right)}\right)\right]$$

Where:

$$\theta_a\left(0.13\frac{L_{air}}{L_{soil}}\right) = n\left(0.43\frac{L_{water}}{L_{soil}}\right) - \theta_w\left(0.3\frac{L_{water}}{L_{soil}}\right);$$

$$n\left(0.43\frac{L_{pore}}{L_{soil}}\right) = 1 - \left(\frac{\rho_b\left(\frac{1.5kg}{L}\right)}{\rho_s\left(\frac{2.65kg}{L}\right)}\right) and$$

$$K_d\left(\frac{L}{kg}\right) = K_{oc}\left(\frac{L}{kg}\right) \times f_{oc}(0.001\ g/g)$$

5.0 Explanation of Supporting Equations and Parameters

5.1 Derivation of the Volatilization Factor

The soil-to-air volatilization factor (VF) is used to define the relationship between the concentration of the contaminant in soil and the flux of the volatilized contaminant to air. VF is calculated from the equation below using chemical-specific properties and either site-measured or default values for soil moisture, dry bulk density, and fraction of organic carbon in soil. The Soil Screening Guidance: User's Guide (U.S. EPA. 1996b) describes how to develop site measured values for these parameters.

The VF is only calculated for volatile organic compounds (VOCs). VOCs, for the purpose of this document, generally are chemicals with a Henry's Law constant greater than or equal to 1 x 10^{-5} atm-m^3/mole and a molecular weight of less than 200 g/mol. Exceptions are: Mercury (elemental); Pyrene; Dibromochloromethane; and 1,2-Dibromo-3-chloropropane.

Because of its reliance on Henry's law, the VF model applies only when the contaminant concentration in soil is at or below saturation (i.e., no free-phase contaminant is present). Soil saturation (Csat) corresponds to the contaminant concentration in soil at which the adsorptive limits of the soil particles and the solubility limits of the available soil moisture have been reached. Above this point, pure liquid-phase contaminant is expected in the soil. If the cleanup level calculated using the VF exceeds the calculated Csat value, the cleanup level is set equal to Csat in accordance with the "Soil Screening Guidance" (U.S. EPA 1996a, 1996b). The equation for the soil saturation limit is presented in section 5.4.

Chemical specific default dermal absorption values are provided in Appendix A and obtained from Supplemental Guidance for Dermal Risk Assessment," Part E of Risk Assessment Guidance for Superfund Human Health Evaluation Manual (Volume I), July 2004 (U.S. EPA. 2004). Chemicals without default dermal absorption values and considered VOC are not quantified. The rationale for this is that in the considered soil exposure scenarios, volatile organic compounds would tend to be volatilized from the soil on skin and should be accounted for via inhalation routes in the combined exposure pathway analysis. Further, a chemical must be a VOC in order to be included in the calculation of groundwater inhalation.

$$VF\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{\frac{Q}{C_{vol}}\left(\frac{\frac{g}{m^2 \cdot s}}{\frac{kg}{m^3}}\right) \times \left(3.14 \times D_A\left(\frac{cm^2}{s}\right) \times T(s)\right)^{1/2} \times 10^{-4}\left(\frac{m^2}{cm^2}\right)}{2 \times \rho_b\left(\frac{g}{cm^3}\right) \times D_A\left(\frac{cm^2}{s}\right)}$$

Where: $\frac{Q}{C_{vol}}\left(\frac{\frac{g}{m^2 \cdot s}}{\frac{kg}{m^3}}\right) = A \times exp\left[\frac{(lnA_S(acre)-B)^2}{C}\right]$

And:

$$D_A\left(\frac{cm^2}{s}\right) = \frac{\left[\frac{\left(\theta_a\left(\frac{L_{air}}{L_{soil}}\right)^{\frac{10}{3}} \times D_{ia}\left(\frac{cm^2}{s}\right) \times H' + \theta_w\left(0.15\frac{L_{water}}{L_{soil}}\right)^{\frac{10}{3}} \times D_{iw}\left(\frac{cm^2}{s}\right)\right)}{n^2\left(\frac{L_{pore}}{L_{soil}}\right)}\right]}{\rho_b\left(1.5\frac{g}{cm^3}\right) \times K_d\left(\frac{cm^3}{g}\right) + \theta_w\left(0.15\frac{L_{water}}{L_{soil}}\right) + \theta_a\left(\frac{L_{air}}{L_{soil}}\right) \times H'}$$

5.2 Selection of Compounds for Dermal Absorption

The single soil cleanup level for each climate zone accounts for the inhalation, ingestion and dermal contact pathways. For those contaminants that are unlikely to undergo significant dermal absorption, the final cleanup level will only reflect the soil ingestion and inhalation pathways.

Dermal absorption of contaminants in soil is calculated based on the Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (EPA, 2004). Where specific absorption factors were not available for an organic compound and it is not considered a volatile, an absorption fraction of 0.10 is applied. It is generally accepted that volatile compounds evaporate from skin before significant absorption occurs and are addressed through the inhalation exposure pathway.

5.3 Particulate Emission Factor (PEF)

Inhalation of contaminants adsorbed to respirable particles (PM10) was assessed using a default PEF equal to 1.36 x 10^9 m^3/kg. This equation relates the contaminant concentration in soil with 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 $\mu g/m^3$. The relationship is derived by Cowherd et al (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 that should be compared with chronic health criteria; it is not appropriate for evaluating the potential for more acute exposures. Definitions of the input variables are in the Standard Defaults Table 7 in Appendix B.

With the exception of specific heavy metals, the PEF does not appear to significantly affect most soil cleanup levels. The equation forms the basis for deriving a generic PEF for the inhalation pathway. For more details regarding specific parameters used in the PEF model, refer to Soil Screening Guidance: Technical Background Document (U.S. EPA. 1996a). The use of alternate values on a specific site should be justified and presented in an Administrative Record if considered in Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedy selection.

Note: the generic PEF evaluates wind-borne emissions and does not consider dust emissions from traffic or other forms of mechanical disturbance that could lead to greater emissions than assumed here.

$$PEF_w\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{Q}{C_w}\left(\frac{\frac{g}{m^2 \cdot s}}{\frac{kg}{m^3}}\right) \times \frac{3{,}600\frac{s}{hour}}{0.036 \times (1 - V) \times \left(\frac{U_m\left(\frac{m}{s}\right)}{U_t\left(\frac{m}{s}\right)}\right)^3 \times F(X)}$$

Where:

$$\frac{Q}{C_w} = A \times exp\left[\frac{(lnA_s(acre) - B)^2}{C}\right]$$

5.4 Derivation of the Soil Saturation Limit (C_{sat})

The soil saturation concentration, Csat, 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 pure solid phases for compounds that are solid at ambient soil temperatures). Csat is not calculated for chemicals that are solid at ambient soil temperatures. The following decision criteria was established from the Soil Screening Guidance User's Guide, Table C-3: if melting point is less than 20 °C, chemical is a liquid; if melting point is above 20 °C, chemical is solid (U.S. EPA. 1996b).

The equation below is used to calculate C_{sat}; for each volatile contaminant. As an update to RAGS HHEM, Part B (U.S. EPA. 1991a), 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.

Chemical-specific C_{sat} concentrations must be compared with each VF-based cleanup level (CL) because a basic principle of 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 that have a VF-based CL that exceeds the C_{sat} concentration are set equal to C_{sat}; whereas for solids (e.g., PAHs), soil cleanup decisions are based on the appropriate CLs for other pathways of concern at the site (e.g., ingestion).

$$C_{sat} = \frac{S\left(\frac{mg}{L}\right)}{\rho_b\left(\frac{kg}{L}\right)} \times \left(K_d\left(\frac{L}{kg}\right) \times \rho_b\left(\frac{kg}{L}\right) + \theta_w\left(\frac{L_{water}}{L_{soil}}\right) + H' \times \theta_a\left(\frac{L_{air}}{L_{soil}}\right) \right)$$

Where:

$$K_d = K_{oc}\left(\frac{L}{kg}\right) \times f_{oc}\left(0.001\frac{g}{g}\right)$$

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right) = n\left(\frac{L_{pore}}{L_{soil}}\right) - \theta_w\left(\frac{L_{water}}{L_{soil}}\right) \; and \; n = 1 - \left(\frac{\rho_b\left(\frac{kg}{L}\right)}{\rho_s\left(\frac{kg}{L}\right)}\right)$$

5.5 Derivation of Dilution Factor

The DEC sets a default dilution factor of 3.3 generated by the following equation:

$$Dilution\ Factor\ (DF) = 1 + \frac{K\left(876\frac{m}{year}\right) \times i\left(0.002\frac{m}{m}\right) \times d(5.5m)}{I\left(0.13\frac{m}{year}\right) \times L(32m)}$$

Where *d*, the mixing zone, is calculated as follows:

$$d(m) = (0.0112 \times L(32m)^2)^{0.5} + d_a(10m) \times \left[1 - exp\left(\frac{-L(32m) \times I\left(0.13\frac{m}{year}\right)}{K\left(876\frac{m}{year}\right) \times i\left(0.002\frac{m}{m}\right) \times d_a(10m)}\right)\right]$$

5.6 Groundwater

5.6.1 B

B is the dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis.

$$B(unitless) = \frac{K_P\left(\frac{cm}{hour}\right)\sqrt{MW\left(\frac{g}{mol}\right)}}{2.6}$$

5.6.2 τ_{event}

τevent is the lag time per event

$$\tau_{event}\left(\frac{hours}{event}\right) = \frac{1}{6 \times 10^{(0.2\ -\ 0.0056 \times MW)}}$$

5.6.3 t*

t* is the time to reach steady state.

$$IF\ B \leq 0.6, then\ t^*(hours) = 2.4 \times \tau_{event}\left(\frac{hours}{event}\right)$$

$$IF\ B > 0.6, then\ t^*(hours) = 6 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(b - \sqrt{b^2 - c^2}\right)$$

Where

$$b = \frac{2 \times (1+B)^2}{\pi} - c$$

And $$c = \frac{1+3B+3B^2}{3(1+B)}$$

6.0 Petroleum Fraction Equations

Cleanup levels for the petroleum fractions presented for soil in Table B2 of 18 AAC 75.340, and for groundwater in Table C of 18 AAC 75.345, are calculated using the following set of equations. These equations were developed using the 1996 EPA Soil Screening Guidance, and remain unchanged from the last update of these cleanup level calculation procedures in June of 2008. Therefore, they do not incorporate the exposure parameters, toxicity values and assumptions of the RSL equations for non-petroleum compounds that are presented in the preceding sections of these procedures. DEC expects to update the equations for calculating the petroleum cleanup criteria as part of a future regulatory update. For chemical specific parameters for the petroleum fractions, refer to Table 1 in Section 6.9.

6.1 Groundwater Cleanup Levels for Petroleum Contaminants

Previously referred to as **Equation 15.**

$$\text{Cleanup Level (mg/L)} = \frac{\text{THQ} \times \text{RfD}_o \times \text{BW} \times \text{AT} \times 365\ \text{d/yr}}{\text{IR} \times \text{EF} \times \text{ED} \times \text{A}}$$

Parameter/Definition (units)	Default
THQ/target hazard quotient (unitless)	1
BW/body weight (kg)	70
AT/averaging time (yr)	30
RfD_o/oral reference dose (mg/kg-d)	Chemical-specific (See Table 1)
EF/exposure frequency (d/yr)	350
ED/exposure duration (yr)	30
IR/ ingestion rate (L/d)	2
A/absorption factor	1
For non-carcinogens, averaging time is equal to exposure duration.	

6.2 Residential Soil Cleanup Levels for Ingestion of Petroleum Fractions

Previously referred to as **Equation 16.**

Cleanup Level (mg/kg) = $\frac{THQ \times BW \times AT \times 365\ d/yr}{1/RfD_o \times 10^{-6}\ kg/mg \times EF \times ED \times IR}$

Parameter/Definition (units)	Default
THQ/target hazard quotient (unitless)	1
BW/body weight (kg)	15
AT/averaging time (yr)	6[a]
RfD_o/oral reference dose (mg/kg-d)	Chemical-specific (See Table 1)
EF/exposure frequency (d/yr)	Arctic Zone = 200 d/yr Under 40 Inch Zone = 270 d/yr Over 40 Inch Zone = 330 d/yr
ED/exposure duration (yr)	6
IR/soil ingestion rate (mg/d)	200

[a] For non-carcinogens, averaging time is equal to exposure duration. Cleanup levels are calculated for 6-year childhood exposure.

6.3 Residential Soil Cleanup Levels for Direct Inhalation of Petroleum Fractions

Previously referred to as **Equation 17.**

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

Parameter/Definition (units)	Default
THQ/target hazard quotient (unitless)	1
AT/averaging time (yr)	30
EF/exposure frequency (d/yr)	Arctic Zone = 200 d/yr Under 40 Inch Zone = 270 d/yr Over 40 Inch Zone = 330 d/yr
ED/exposure duration (yr)	30
RfC/inhalation reference concentration (mg/m^3)	Chemical-specific (See Table 1)
VF/soil-to-air volatilization factor (m^3/kg)	Chemical-specific (See Equation 18)

6.4 Derivation of the Volatilization Factor

Previously referred to as **Equation 18.**

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

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)	---	
Q/C/inverse of the mean conc. at the center of a 0.5 acre square source (g/m^2-s per kg/m^3)	Arctic Zone	=101.5958
	Under 40 Inch Zone	=90.80
	Over 40 Inch Zone	=82.72
T/exposure interval (s)	8.2×10^8	
ρ_b/dry soil bulk density (g/cm^3)	1.5	
ρ_s/soil particle density (g/cm^3)	2.65	
n/total soil porosity (L_{pore}/L_{soil})	0.43 or 1 - (ρ_b/ρ_s)	
θ_w/water-filled soil porosity (L_{water}/L_{soil})	0.15 or $w\rho_b$	
θ_a/air-filled soil porosity (L_{air}/L_{soil})	0.28 or n - $w\rho_b$	
D_i/diffusivity in air (cm^2/s)	Chemical-specific (See Table 1)	
H'/ dimensionless Henry's law constant	Chemical-specific (See Table 1)	
w/average soil moisture content $kg_{water}/kg_{soil\text{-}dry}$	0.1 (10%)	
D_w/diffusivity in water (cm^2/s)	Chemical-specific (See Table 1)	
K_d/soil-water partition coefficient (cm^3/g)	K_{oc} x f_{oc} (organics)	
K_{oc}/organic carbon partition coefficient (cm^3/g)	Chemical-specific (See Table 1)	
f_{oc}/organic carbon content of soil (g/g)	0.001 (0.1%)	

6.5 Derivation of the Soil Saturation Limit

Previously referred to as **Equation 19.** Note: The Soil Saturation Limit will be used as an upper limit for petroleum for the Inhalation Pathway Calculations

$$C_{sat}\ (mg/kg) = \frac{S}{\rho_b}\ (K_d\ \rho_b + \theta_w + H'\theta_a)$$

Parameter/Definition (units)	Default
C_{sat}/soil saturation concentration (mg/kg)	---
S/solubility in water (mg/L-water)	Chemical-specific (See Table 1)
ρ_b/dry soil bulk density (kg/L)	1.5
ρ_s/soil particle density (kg/L)	2.65
n/total soil porosity (L_{pore}/L_{soil})	0.434 or 1 - (ρ_b / ρ_s)
θ_w/water-filled soil porosity (L_{water}/L_{soil})	0.15 or $w\rho_b$
θ_a/air-filled soil porosity (L_{air}/L_{soil})	0.284 or n - $w\rho_b$
K_d/soil-water partition coefficient (L/kg)	K_{oc} x f_{oc}
K_{oc}/soil organic carbon/water partition coefficient (L/kg)	Chemical-specific (See Table 1)
f_{oc}/fraction organic carbon of soil (g/g)	0.001 (0.1%)
w/average soil moisture content $kg_{water}/kg_{soil\text{-}dry}$	0.1 (10%)
H'/Henry's law constant (unitless)	Chemical-specific (See Table 1)

6.6 Soil-Water Partitioning Equation for Migration to Groundwater for Petroleum Fractions

Previously referred to as **Equation 20.**

$$\text{Soil cleanup level (mg/kg)} = C_w\ \{(K_{oc}\ f_{oc}) + ((\theta_w + \theta_a H')/\ \rho_b)\}$$

Parameter/Definition (units)	Default
C_w/target soil leachate concentration (mg/L)	Groundwater Cleanup Level x (10 + DF), 10 is attenuation factor
K_{oc}/soil organic carbon/water partition coefficient (L/kg)	Chemical-specific (See Table 1)
f_{oc}/fraction organic carbon in soil (g/g)	0.001 (0.1%)
ρ_b/dry soil bulk density (kg/L)	1.5
ρ_s/soil particle density (kg/L)	2.65
n/total soil porosity (L_{pore}/L_{soil})	0.434 or (1 - ρ_b/ρ_s)
θ_w/water-filled soil porosity (L_{water}/L_{soil})	0.3 (30%) or $w\rho_b$
θ_a/air-filled soil porosity (L_{air}/L_{soil})	0.13 or n -$w\rho_b$
w/average soil moisture content $kg_{water}/kg_{soil\text{-}dry}$	0.2 (20%)
H'/Henry's law constant (unitless)	Chemical Specific (See Table 1)

6.7 Derivation of Dilution Factor

Previously referred to as **Equation 21.**

$DF = 1 + (Kid / IL)$	
Parameter/Definition (units)	Default
DF/dilution factor (unitless)	---
K/aquifer hydraulic conductivity (m/yr)	876 m/yr
i/hydraulic gradient (m/m)	0.002 m/m
d/mixing zone depth (m)	(See Equation 22 below)
I/infiltration rate (m/yr) (calculated as 1/5 * (mean plus one standard deviation of yearly rainfall))	Over 40 Inch Zone =0.6 m/yr Under 40 Inch Zone =0.13 m/yr
L/source length parallel to groundwater flow (m)	32 m
The standard default dilution factors used to determine the cleanup standards are DF = 1.9 for the Over 40 Inch Zone; and DF = 3.3 for the Under 40 Inch Zone.	

6.8 Estimation of Mixing Zone Depth

Previously referred to as **Equation 22.**

$d = (0.0112L^2)^{0.5} + d_a\{1 - \exp[(-LI)/(Kid_a)]\}$	
Parameter/Definition (units)	Default
d/mixing zone depth (m)	---
L/source length parallel to groundwater flow (m)	32 m
I/infiltration rate (m/yr) (calculated as 1/5 * (mean plus one standard deviation of yearly rainfall))	Over 40 Inch Zone =0.6 m/yr Under 40 Inch Zone =0.13 m/yr
K/aquifer hydraulic conductivity (m/yr)	876 m/yr
i/hydraulic gradient (m/m)	0.002
d_a/aquifer thickness (m)	10 m
The standard default mixing zone depths used to determine the cleanup standards are: d = 10.0 for the Over 40 Inch Zone; and d = 5.5 for the Under 40 Inch Zone.	

6.9 Chemical Specific Parameters

Table 1- Chemical Specific Parameters for Petroleum Hydrocarbon Fractions							
HENRY'S LAW CONSTANT, H' (unitless)							
aromatics				$\log_{10} H = [-0.23][EC] + 1.7$			
aliphatics				$\log_{10} H = [0.02][EC] + 1.6$			
ORGANIC CARBON PARTITION COEFFICIENT, Koc (ml/g)							
aromatics				$\log_{10} Koc = [0.10][EC] + 2.3$			
Aliphatics				$\log_{10} Koc = [0.45][EC] + 0.43$			
Hydrocarbon Range	Equivalent Carbon Number (EC)	Oral Reference Dose (mg/kg/day)	Reference Concentration (mg/m^3)	H' (unitless)	Koc	Diffusivity in Air	Diffusivity in Water
C_6-C_{10} Aliphatics	8	5	18.4	5.75 E+1	1.07 E+4	1 E-1	1 E-5
C_6-C_{10} Aromatics	8	0.2	0.4	7.24 E-1	1.26 E+3	1 E-1	1 E-5
C_{10}-C_{25} Aliphatics	14	0.1	1	7.59 E+1	5.37 E+6	1 E-1	1 E-5
C_{10}-C_{25} Aromatics	14	0.04	0.2	3.02 E-2	5.01 E+3	1 E-1	1 E-5
C_{25}-C_{36} Aliphatics	30.5	2	n/a				
C_{25}-C_{36} Aromatics	30.5	0.03	n/a	4.86 E-6	2.24 E+5	1 E-1	1 E-5

*Note that no values are recommended for the C_{25}-C_{36} aliphatic fraction, as these compounds are essentially immobile in the environment.

6.10 Total Gasoline, Diesel, and Residual Range Organics (GRO, DRO, and RRO) Versus Aromatic/Aliphatic Fractions

Table B2 soil cleanup levels for petroleum hydrocarbons (GRO, DRO, and RRO) are based on Methods AK 101, 102, and 103. The Table B2 GRO, DRO, and RRO levels were derived based on assumed default percentages of aromatic and aliphatic fractions within each carbon range. The Table B2 aliphatic/aromatic fractional cleanup levels were transformed into the GRO, DRO, and RRO levels by dividing the aromatic or aliphatic cleanup level by a corresponding aromatic or aliphatic default percentage.

DEC selected the default compositions of GRO, DRO, and RRO shown in Table 2.

Table 2: Petroleum Hydrocarbon Default Compositions

CARBON RANGE	PERCENT ALIPHATIC*	PERCENT AROMATIC*
GRO - C_6 - C_{10}	70	50
DRO - C_{10} - C_{25}	80	40
RRO - C_{25} - C_{36}	90	30

*Note - Because fuel constituents vary considerably, the default composition of the percent aliphatic and percent aromatics was set at 120% of the total.

For example, the C10-C25 DRO cleanup levels in Table B2 were calculated by dividing the corresponding C10-C25 aliphatic level by 0.80 and also dividing the corresponding C10-C25 aromatic level by 0.40. The lowest result of these two calculations became the method two C10-C25 DRO cleanup level (TPHCWG, 1997).

7.0 Calculating Cleanup Levels under Method Three

Table B1 Contaminants

Alternative residential soil cleanup levels may be developed under method three (18 AAC 75.340(e)) utilizing site-specific data for the soil migration to groundwater pathway. Site-specific parameters that may be modified for Table B1 compounds are listed in Table 3. Equations for the Table B1 contaminants are found in Sections 2.0 through 4.0.

Table 3 – Site-Specific Parameters for Table B1 Compounds		
Parameters[1]	Definition (units)	Default Value
f_{oc}	Fractional organic carbon (g/g)	0.001 (1%)
ρ_b	dry soil bulk density (kg/L)	1.5
θw	water-filled soil porosity (L_{water}/L_{soil})	0.15
ρ_s	Soil particle density (kg/L)	2.65
K	Aquifer hydraulic conductivity (m/year)	876
L	Source length parallel to ground water flow (m)	32
d_a	Aquifer thickness (m)	10
I	Hydraulic gradient (m/m)	0.002
I	Infiltration rate (m/yr)	0.13
AF	Attenuation Factor (unitless)	4

Table B2 Petroleum Fractions

Alternative residential soil cleanup levels may be developed under method three (18 AAC 75.340(e)) utilizing site-specific data for the soil migration to groundwater pathway. Site-specific parameters that may be modified for Table B2 petroleum fractions are listed in Table 4. Equations for the petroleum fractions are in Section 6.0.

Table 4 – Site-Specific Parameters for Petroleum Fraction Equations		
Parameters[1]	Definition (units)	Default Value
f_{oc}	Fractional organic carbon (g/g)	0.001 (1%)
ρ_b	dry soil bulk density (kg/L)	1.5
n	total soil porosity (L_{pore}/L_{soil})	0.434 or (1 - ρ_b/ρ_s)
θw	water-filled soil porosity (L_{water}/L_{soil})	0.15 or $w\rho_b$
θa	air-filled soil porosity (L_{air}/L_{soil})	0.284 or n - $w\rho_b$
w	average soil moisture content kg_{water}/kg_{soil}-dry	0.1 (10%)
K	Aquifer hydraulic conductivity (m/yr)	876 m/yr
i	Hydraulic gradient (m/m)	0.002 m/m
d	Mixing zone depth (m)	See Mixing Zone Depth Equation 22
I	Infiltration rate (m/yr)	>40 inch zone =0.6m/yr <40 inch zone = 0.13 m/yr
L	Source length parallel to groundwater flow (m)	32 m
d_a	Aquifer thickness (m)	10 m

For either Table B1 or B2 contaminants, if a site-specific dry soil bulk density will be used, then the total porosity, air-filled porosity, and water-filled porosity must be calculated using the appropriate equation the respective contaminant. Note that the air-filled soil porosity is the portion of the total porosity of soil containing air. This value is calculated by subtracting the water-filled porosity from the total soil porosity. If a site-specific total soil porosity or water-filled soil porosity is determined for a site, then the air-filled soil porosity should be reviewed to ensure that the sum of the air-filled and water-filled soil porosities equals the total soil porosity.

A standard default mixing zone depth has been adopted by the department for application to Table B1 contaminants. This value cannot be modified. However, for Table B2 petroleum fractions, this value can be modified using site-specific information (see Table 4).

Commercial/Industrial Land Use Scenario

Alternative soil cleanup levels may also be proposed for commercial/industrial exposure scenarios under method three. However, sites where a commercial/industrial exposure scenario is proposed requires an institutional control to ensure that the land use remains commercial industrial in perpetuity, unless a future cleanup action is performed that brings the site into compliance with a residential exposure scenario. Values for parameters that are applied for this scenario are shown in Table 5.

Table 5- Commercial/Industrial Exposure Parameters

Parameters	Definition (units)	Value
AT	averaging time for carcinogens (years)	70 (unchanged from residential)
AT	averaging time for non-carcinogens (years)	25
BW	body weight (kg)	80
ED	exposure duration (years)	25
EF	exposure frequency (days/years)	250 (under 40 inch and over 40 inch zones) 200 (arctic zone)
IRsoil	soil ingestion rate (mg/day)	100 (outdoor worker) 50 (indoor worker)
SA	Surface Area	3527 cm^2
AF	Adherence Factors	0.12 mg/cm^2

For additional guidance on the equations for and calculation of commercial/industrial cleanup levels, reference the EPA Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (U.S. EPA. 2002).

8.0 References

ADEC (Alaska Department of Environmental Conservation). 2015. Risk Assessment Procedures Manual.

Calabrese, Edward J., Ramon Barnes, Edward J. Stanek III, Harris Pastides, Charles E. Gilbert, Peter Veneman, Xioaru Wang, Alexandra Lasztity, Paul T. Kostecki, How much soil do young children ingest: An epidemiologic study, Regulatory Toxicology and Pharmacology, Volume 10, Issue 2, October 1989, Pages 123-137, ISSN 0273-2300, 10.1016/0273-2300(89)90019-6. (http://www.sciencedirect.com/science/article/pii/0273230089900196)

Cowherd, C., G.E. Muleski, P.J. Englehart, and D.A. Gillette. 1985. Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites. Kansas City, MO. Midwest Research Institute. PB85-192219.

Davis, Scott, et al. "Quantitative estimates of soil ingestion in normal children between the ages of 2 and 7 years: population-based estimates using aluminum, silicon, and titanium as soil tracer elements." *Archives of Environmental Health: An International Journal* 45.2 (1990): 112-122.

Harding Lawson Associates. 1995. Final Report Cleanup Level Matrix for Hazardous Substances in Soil Various Sites, Alaska.

TPHCWG (Total Petroleum Hydrocarbon Criteria Working Group) 1997. Vol. 1-5, Amherst Scientific Publishers. ISBN 1-884-940-13-7.

U.S. EPA (Environmental Protection Agency). 1987. Processes, Coefficients, and Models for Simulation Toxic Organics and Heavy Metals in Surface Waters. EPA/600/3-87/015. Office of Research and Development, Athens, GA.

U.S. EPA. 1989. Risk assessment Guidance for Superfund. Volume I: Human health evaluation manual (Part A). Interim Final. Office of Emergency and Remedial Response. EPA/540/1-89/002.

U.S. EPA. 1991a. Human health evaluation manual, supplemental guidance: "Standard default exposure factors". OSWER Directive 9285.6-03.

U.S. EPA. 1991b. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals). Office of Emergency and Remedial Response. EPA/540/R-92/003. December 1991

U.S. EPA. 1996a. Soil Screening Guidance: Technical Background Document. Office of Emergency and Remedial Response. Washington, DC. OSWER No. 9355.4-17A
http://www.epa.gov/superfund/health/conmedia/soil/introtbd.htm

U.S. EPA. 1996b. Soil Screening Guidance: User's Guide. Office of Emergency and Remedial Response. Washington, DC. OSWER No. 9355.4-23
http://www.epa.gov/superfund/health/conmedia/soil/index.htm#user

U.S. EPA. 1997a. Exposure Factors Handbook. Office of Research and Development, Washington, DC. EPA/600/P-95/002Fa.

U.S. EPA. 2000. Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds. Part I: Estimating Exposure to Dioxin-Like Compounds. Volume 3--Properties, Environmental Levels, and Background Exposures. Draft Final Report. EPA/600/P- 00/001. Office of Research and Development, Washington, DC. September.

U.S. EPA. 2001. WATER9. Version 1.0.0. Office of Air Quality Planning and Standards, Research Triangle Park, NC. Web site at: http://www.epa.gov/ttn/chief/software/water/index.html

U.S. EPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. December 2002.
http://www.epa.gov/superfund/health/conmedia/soil/index.htm

U.S. EPA. 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. OSWER 9285.7-02EP.July 2004. Document and website:
http://www.epa.gov/oswer/riskassessment/ragse/index.htm

U.S. EPA. 2009. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment) Final. OSWER 9285.7-82. January 2009. Document, memo and website:
http://www.epa.gov/oswer/riskassessment/ragsf/index.htm

U.S. EPA 2012. Regional Screening Table – User's Guide. Available at:
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm.

Van Wijnen, J. H., P. Clausing, and B. Brunekreef. Estimated soil ingestion by children. Environmental research 51.2 (1990): 147-162

Appendix A – Toxicity and Chemical Specific Parameters for Non-Petroleum Organic and Inorganic Contaminants

Symbol	Definition
GIABS	Fraction of contaminant absorbed in gastrointestinal tract (unitless) Note: if the GIABS is >50% then it is set to 100% for the calculation of dermal toxicity values.
ABS	Fraction of contaminant absorbed dermally from soil (unitless)
RBA	Relative bioavailability factor
Ingestion SF	Chronic Oral Slope Factor (mg/kg-day)-1
IUR	Chronic Inhalation Unit Risk (ug/m3)-1
RfD	Chronic Oral Reference Dose (mg/kg-day)
RfC	Chronic Inhalation Reference Concentration (mg/m3)
D_a	Diffusivity in air (cm2/hour)
D_w	Diffusivity in water (cm2/hour)
S	Water Solubility Limit (mg/L)
K_d	Soil-water partition coefficient (L/kg) (Koc* foc)
K_{oc}	Soil organic carbon/water partition coefficient (L/kg)
H'	Dimensionless Henry's Law Constant (unitless)
MW	Molecular Weight (g/mol)
FA	Systemically available fraction
K_p	Dermal permeability coefficient in water (cm/hour)
MP	Melting Point (°C)

Table 6 Chemical Toxicity Parameters

CAS Number[1]	Compound	GIABS	ABS	RBA	Ingestion SF (mg/kg day)$^{-1}$	Ref[2]	Inhalation Unit Risk ($\mu g/m^3$)$^{-1}$	Ref[2]	Chronic RfD (mg/kg day)	Ref[2]	Chronic RfC (mg/m^3)	Ref[2]
83-32-9	Acenaphthene	1	0.13	1	-		-		0.06	I	-	
208-96-8	Acenaphthylene[4]	1	0.13	1	-		-		0.03	S	-	
67-64-1	Acetone	1	-	1	-		-		0.9	I	30.880981595092	A
309-00-2	Aldrin	1	-	1	17	I	0.0049	I	0.00003	I	-	
7790-98-9	Ammonium Perchlorate	1	-	1	-		-		0.0007	I	-	
120-12-7	Anthracene	1	0.13	1	-		-		0.3	I	-	
7440-36-0	Antimony (metallic)	0.15	-	1	-		-		0.0004	I	-	
7440-38-2	Arsenic, Inorganic	1	0.03	0.6	1.5	I	0.0043	I	0.0003	I	0.000015	C
7440-39-3	Barium	0.07	-	1	-		-		0.2	I	0.0005	H
56-55-3	Benz[a]anthracene[3]	1	0.13	1	0.73	S	0.00011	C	-		-	
100-52-7	Benzaldehyde	1	-	1	0.004	P	-		0.1	I	-	
71-43-2	Benzene	1	-	1	0.055	I	7.8×10^{-6}	I	0.004	I	0.03	I
50-32-8	Benzo[a]pyrene	1	0.13	1	7.3	I	0.0011	C	-		-	
205-99-2	Benzo[b]fluoranthene[3]	1	0.13	1	0.73	S	0.00011	C	-		-	
191-24-2	Benzo[g,h,i]perylene[4]	1	0.13	1	-		-		0.03	S	-	
207-08-9	Benzo[k]fluoranthene[3]	1	0.13	1	0.073	S	0.00011	C	-		-	
65-85-0	Benzoic Acid	1	0.1	1	-		-		4	I	-	
100-51-6	Benzyl Alcohol	1	0.1	1	-		-		0.1	P	-	
7440-41-7	Beryllium and compounds	0.007	-	1	-		0.0024	I	0.002	I	0.00002	I
111-44-4	Bis(2-chloroethyl)ether	1	-	1	1.1	I	0.00033	I	-		-	
117-81-7	Bis(2-ethylhexyl)phthalate	1	0.1	1	0.014	I	2.4×10^{-6}	C	0.02	I	-	
108-86-1	Bromobenzene	1	-	1	-		-		0.008	I	0.06	I
75-27-4	Bromodichloromethane	1	-	1	0.062	I	0.000037	C	0.02	I	-	
75-25-2	Bromoform	1	-	1	0.0079	I	1.1×10^{-6}	I	0.02	I	-	
74-83-9	Bromomethane	1	-	1	-		-		0.0014	I	0.005	I
106-99-0	Butadiene, 1,3-	1	-	1	3.4	C	0.00003	I	-		0.002	I
71-36-3	Butanol, N-	1	-	1	-		-		0.1	I	-	
85-68-7	Butyl Benzyl Phthalate	1	0.1	1	0.0019	P	-		0.2	I	-	
104-51-8	Butylbenzene, n-	1	-	1	-		-		0.05	P	-	
135-98-8	Butylbenzene, sec-	1	-	1	-		-		0.1	X	-	
98-06-6	Butylbenzene, tert-	1	-	1	-		-		0.1	X	-	
7440-43-9	Cadmium (Diet)	0.025	0.001	1	-		0.0018	I	0.001	I	1.0×10^{-5}	A
7440-43-9	Cadmium (Water)				-		0.0018	I	0.0005	I	1.0×10^{-5}	A
75-15-0	Carbon Disulfide	1	-	1	-		-		0.1	I	0.7	I
56-23-5	Carbon Tetrachloride	1	-	1	0.07	I	6.0×10^{-6}	I	0.004	I	0.1	I
12789-03-6	Chlordane	1	0.04	1	0.35	I	0.0001	I	0.0005	I	0.0007	I
143-50-0	Chlordecone (Kepone)	1	0.1	1	10	I	0.0046	C	0.0003	I	-	
106-47-8	Chloroaniline, p-	1	0.1	1	0.2	P	-		0.004	I	-	
108-90-7	Chlorobenzene	1	-	1	-		-		0.02	I	0.05	P
67-66-3	Chloroform	1	-	1	0.031	C	2.3×10^{-5}	I	0.01	I	0.09765235173824	A
74-87-3	Chloromethane	1	-	1	-		-		-		0.09	I

CAS Number[1]	Compound	GIABS	ABS	RBA	Ingestion SF (mg/kg day)$^{-1}$	Ref[2]	Inhalation Unit Risk (µg/m^3)$^{-1}$	Ref[2]	Chronic RfD (mg/kg day)	Ref[2]	Chronic RfC (mg/m^3)	Ref[2]
91-58-7	Chloronaphthalene, Beta-	1	0.13	1	-		-		0.08	I	-	
95-57-8	Chlorophenol, 2-	1	-	1	-		-		0.005	I	-	
16065-83-1	Chromium(III), Insoluble Salts	0.013	-	1	-		-		1.5	I	-	
18540-29-9	Chromium(VI)	0.025	-	1	0.5	J	0.084	I	0.003	I	0.0001	I
218-01-9	Chrysene[3]	1	0.13	1	0.0073	S	0.000011	C	-		-	
7440-50-8	Copper	1	-	1	-		-		0.04	H	-	
108-39-4	Cresol, m-	1	0.1	1	-		-		0.05	I	0.6	C
95-48-7	Cresol, o-	1	0.1	1	-		-		0.05	I	0.6	C
106-44-5	Cresol, p-	1	0.1	1	-		-		0.1	A	0.6	C
98-82-8	Cumene	1	-	1	-		-		0.1	I	0.4	I
57-12-5	Cyanide (CN-)[5]	1	-	1	-		-		0.0006	I	0.0008	S
110-82-7	Cyclohexane	1	-	1	-		-		-		6	I
72-54-8	DDD	1	0.1	1	0.24	I	0.000069	C	-		-	
72-55-9	DDE, p,p'-	1	-	1	0.34	I	0.000097	C	-		-	
50-29-3	DDT	1	0.03	1	0.34	I	0.000097	I	0.0005	I	-	
53-70-3	Dibenz[a,h]anthracene[3]	1	0.13	1	7.3	S	0.0012	C	-		-	
132-64-9	Dibenzofuran	1	0.03	1	-		-		0.001	X	-	
124-48-1	Dibromochloromethane	1	-	1	0.084	I	-		0.02	I	-	
106-93-4	Dibromoethane, 1,2-	1	-	1	2	I	0.0006	I	0.009	I	0.009	I
74-95-3	Dibromomethane (Methylene Bromide)	1	-	1	-		-		-		0.004	X
84-74-2	Dibutyl Phthalate	1	0.1	1	-		-		0.1	I	-	
95-50-1	Dichlorobenzene, 1,2-	1	-	1	-		-		0.09	I	0.2	H
541-73-1	Dichlorobenzene, 1,3-[6]	1	-	1	-		-		0.09	S	0.2	S
106-46-7	Dichlorobenzene, 1,4-	1	-	1	0.0054	C	0.000011	C	0.07	A	0.8	I
91-94-1	Dichlorobenzidine, 3,3'-	1	0.1	1	0.45	I	0.00034	C	-		-	
75-71-8	Dichlorodifluoromethane	1	-	1	-		-		0.2	I	0.1	X
75-34-3	Dichloroethane, 1,1-	1	-	1	0.0057	C	1.6×10^{-6}	C	0.2	P	-	
107-06-2	Dichloroethane, 1,2-	1	-	1	0.091	I	0.000026	I	0.006	X	0.007	P
75-35-4	Dichloroethylene, 1,1-	1	-	1	-		-		0.05	I	0.2	I
156-59-2	Dichloroethylene, 1,2-cis-	1	-	1	-		-		0.002	I	-	
156-60-5	Dichloroethylene, 1,2-trans-	1	-	1	-		-		0.02	I	-	
120-83-2	Dichlorophenol, 2,4-	1	0.1	1	-		-		0.003	I	-	
94-75-7	Dichlorophenoxy Acetic Acid, 2,4-	1	0.05	1	-		-		0.01	I	-	
78-87-5	Dichloropropane, 1,2-	1	-	1	0.036	C	1.0×10^{-5}	C	0.09	A	0.004	I
542-75-6	Dichloropropene, 1,3-	1	-	1	0.1	I	4.0×10^{-6}	I	0.03	I	0.02	I
60-57-1	Dieldrin	1	0.1	1	16	I	0.0046	I	0.00005	I	-	
84-66-2	Diethyl Phthalate	1	0.1	1	-		-		0.8	I	-	
105-67-9	Dimethylphenol, 2,4-	1	0.1	1	-		-		0.02	I	-	
131-11-3	Dimethylphthalate[7]	1	0.1	1	-		-		0.8	S	-	
528-29-0	Dinitrobenzene, 1,2-	1	0.1	1	-		-		0.0001	P	-	
99-65-0	Dinitrobenzene, 1,3-	1	0.1	1	-		-		0.0001	I	-	
100-25-4	Dinitrobenzene, 1,4-	1	0.1	1	-		-		0.0001	P	-	
51-28-5	Dinitrophenol, 2,4-	1	0.1	1	-		-		0.002	I	-	
121-14-2	Dinitrotoluene, 2,4-	1	0.102	1	0.31	C	0.000089	C	0.002	I	-	

CAS Number[1]	Compound	GIABS	ABS	RBA	Ingestion SF (mg/kg day)$^{-1}$	Ref[2]	Inhalation Unit Risk ($\mu g/m^3$)$^{-1}$	Ref[2]	Chronic RfD (mg/kg day)	Ref[2]	Chronic RfC (mg/m^3)	Ref[2]
606-20-2	Dinitrotoluene, 2,6-	1	0.099	1	1.5	P	-		0.0003	X	-	
35572-78-2	Dinitrotoluene, 2-Amino-4,6-[13]	1	0.006	1	-		-		0.002	S	-	
19406-51-0	Dinitrotoluene, 4-Amino-2,6-[13]	1	0.009	1	-		-		0.002	S	-	
123-91-1	Dioxane, 1,4-	1	-	1	0.1	I	5×10^{-6}	I	0.03	I	0.03	I
122-39-4	Diphenylamine	1	0.1	1	-		-		0.025	I	-	
115-29-7	Endosulfan	1	-	1	-		-		0.006	I	-	
72-20-8	Endrin	1	0.1	1	-		-		0.0003	I	-	
75-00-3	Ethyl Chloride	1	-	1	-		-		-		10	I
100-41-4	Ethylbenzene	1	-	1	0.011	C	2.5×10^{-6}	C	0.1	I	1	I
107-21-1	Ethylene Glycol	1	0.1	1	-		-		2	I	0.4	C
206-44-0	Fluoranthene	1	0.13	1	-		-		0.04	I	-	
86-73-7	Fluorene	1	0.13	1	-		-		0.04	I	-	
50-00-0	Formaldehyde	1	-	1	-		0.000013	I	0.2	I	0.00982576687116	A
76-44-8	Heptachlor	1	-	1	4.5	I	0.0013	I	0.0005	I	-	
1024-57-3	Heptachlor Epoxide	1	-	1	9.1	I	0.0026	I	0.000013	I	-	
118-74-1	Hexachlorobenzene	1	-	1	1.6	I	0.00046	I	0.0008	I	-	
87-68-3	Hexachlorobutadiene	1	-	1	0.078	I	0.000022	I	0.001	P	-	
319-84-6	Hexachlorocyclohexane, Alpha-	1	0.1	1	6.3	I	0.0018	I	0.008	A	-	
319-85-7	Hexachlorocyclohexane, Beta-	1	0.1	1	1.8	I	0.00053	I	-		-	
58-89-9	Hexachlorocyclohexane, Gamma- (Lindane)	1	0.04	1	1.1	C	0.00031	C	0.0003	I	-	
77-47-4	Hexachlorocyclopentadiene	1	-	1	-		-		0.006	I	0.0002	I
67-72-1	Hexachloroethane	1	-	1	0.04	I	0.000011	C	0.0007	I	0.03	I
121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	1	0.015	1	0.11	I	-		0.003	I	-	
110-54-3	Hexane, N-	1	-	1	-		-		-		0.7	I
591-78-6	Hexanone, 2-	1	-	1	-		-		0.005	I	0.03	I
302-01-2	Hydrazine	1	-	1	3	I	0.0049	I	-		0.00003	P
193-39-5	Indeno[1,2,3-cd]pyrene[3]	1	0.13	1	0.73	S	0.00011	C	-		-	
78-59-1	Isophorone	1	0.1	1	0.00095	I	-		0.2	I	2	C
67-63-0	Isopropanol	1	-	1	-		-		2	P	0.2	P
7439-92-1	Lead and Compounds[8]	1	-	1	-		-		-		-	
7487-94-7	Mercuric Chloride[9]	0.07	-	1	-		-		0.0003	I	0.0003	S
7439-97-6	Mercury (elemental)	1	-	1	-		-		0.00016	C	0.0003	I
67-56-1	Methanol	1	-	1	-		-		2	I	20	I
72-43-5	Methoxychlor	1	0.1	1	-		-		0.005	I	-	
78-93-3	Methyl Ethyl Ketone (2-Butanone)	1	-	1	-		-		0.6	I	5	I
108-10-1	Methyl Isobutyl Ketone (4-methyl-2-pentanone)	1	-	1	-		-		-		3	I
22967-92-6	Methyl Mercury	1	-	1	-		-		0.0001	I	-	
1634-04-4	Methyl tert-Butyl Ether (MTBE)	1	-	1	0.0018	C	2.6×10^{-7}	C	-		3	I
75-09-2	Methylene Chloride	1	-	1	0.002	I	1×10^{-8}	I	0.006	I	0.6	I
90-12-0	Methylnaphthalene, 1-	1	0.13	1	0.029	P	-		0.07	A	-	
91-57-6	Methylnaphthalene, 2-	1	0.13	1	-		-		0.004	I	-	
91-20-3	Naphthalene	1	0.13	1	-		0.000034	C	0.02	I	0.003	I
7440-02-0	Nickel Soluble Salts	0.04	-	1	-		0.00026	C	0.02	I	0.00009	A
98-95-3	Nitrobenzene	1	-	1	-		0.00004	I	0.002	I	0.009	I

Sulfonate XCT

CAS Number[1]	Compound	GIABS	ABS	RBA	Ingestion SF (mg/kg day)$^{-1}$	Ref[2]	Inhalation Unit Risk ($\mu g/m^3$)$^{-1}$	Ref[2]	Chronic RfD (mg/kg day)	Ref[2]	Chronic RfC (mg/m^3)	Ref[2]
55-63-0	Nitroglycerin	1	0.1	1	0.017	P	-		0.0001	P	-	
556-88-7	Nitroguanidine	1	0.1	1	-		-		0.1	I	-	
62-75-9	Nitrosodimethylamine, N-	1	-	1	51	I	0.014	I	8×10^{-5}	P	0.00004	X
621-64-7	Nitroso-di-N-propylamine, N-	1	0.1	1	7	I	0.002	C	-		-	
86-30-6	Nitrosodiphenylamine, N-	1	0.1	1	0.0049	I	2.6×10^{-6}	C	-		-	
99-08-1	Nitrotoluene, m-	1	0.1	1	-		-		0.0001	X	-	
88-72-2	Nitrotoluene, o-	1	-	1	0.22	P	-		0.0009	P	-	
99-99-0	Nitrotoluene, p-	1	0.1	1	0.016	P	-		0.004	P	-	
2691-41-0	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	1	0.006	1	-		-		0.05	I	-	
117-84-0	Octyl Phthalate, di-N-	1	0.1	1	-		-		0.01	P	-	
87-86-5	Pentachlorophenol	1	0.25	1	0.4	I	5.1×10^{-6}	C	0.005	I	-	
78-11-5	Pentaerythritol tetranitrate (PETN)	1	0.1	1	0.004	X	-		0.002	P	-	
1763-23-1	Perfluorooctane Sulphonic Acid (PFOS)[10]	1	0.1	1	-		-		0.00002	W	-	
335-67-1	Perfluorooctanoic Acid (PFOA)[11]	1	0.1	1	0.07	W	-		0.00002	W	-	
85-01-8	Phenanthrene[4]	1	0.13	1	-		-		0.03	S	-	
108-95-2	Phenol	1	0.1	1	-		-		0.3	I	0.2	C
7723-14-0	Phosphorus, White	1	-	1	-		-		0.00002	I	-	
1336-36-3	Polychlorinated Biphenyls[14]	1	0.14	1	2	I	0.00057142857142	I	-		-	
103-65-1	Propyl benzene	1	-	1	-		-		0.1	X	1	X
129-00-0	Pyrene	1	0.13	1	-		-		0.03	I	-	
7782-49-2	Selenium	1	-	1	-		-		0.005	I	0.02	C
7440-22-4	Silver	0.04	-	1	-		-		0.005	I	-	
100-42-5	Styrene	1	-	1	-		-		0.2	I	1	I
1746-01-6	TCDD, 2,3,7,8-[12]	1	0.03	1	130000	C	38	C	7×10^{-10}	I	4×10^{-8}	C
630-20-6	Tetrachloroethane, 1,1,1,2-	1	-	1	0.026	I	7.4×10^{-6}	I	0.03	I	-	
79-34-5	Tetrachloroethane, 1,1,2,2-	1	-	1	0.2	I	0.000058	C	0.02	I	-	
127-18-4	Tetrachloroethylene	1	-	1	0.0021	I	2.6×10^{-7}	I	0.006	I	0.04	I
479-45-8	Tetryl (Trinitrophenylmethylnitramine)	1	0.00065	1	-		-		0.002	P	-	
7440-28-0	Thallium (Soluble Salts)	1	-	1	-		-		1×10^{-5}	X	-	
108-88-3	Toluene	1	-	1	-		-		0.08	I	5	I
8001-35-2	Toxaphene	1	0.1	1	1.1	I	0.00032	I	-		-	
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2-	1	-	1	-		-		30	I	30	H
87-61-6	Trichlorobenzene, 1,2,3-	1	-	1	-		-		0.0008	X	-	
120-82-1	Trichlorobenzene, 1,2,4-	1	-	1	0.029	P	-		0.01	I	0.002	P
71-55-6	Trichloroethane, 1,1,1-	1	-	1	-		-		2	I	5	I
79-00-5	Trichloroethane, 1,1,2-	1	-	1	0.057	I	0.000016	I	0.004	I	0.0002	X
79-01-6	Trichloroethylene	1	-	1	0.046	I	4.1×10^{-6}	I	0.0005	I	0.002	I
75-69-4	Trichlorofluoromethane	1	-	1	-		-		0.3	I	-	
95-95-4	Trichlorophenol, 2,4,5-	1	0.1	1	-		-		0.1	I	-	
88-06-2	Trichlorophenol, 2,4,6-	1	0.1	1	0.011	I	3.1×10^{-6}	I	0.001	P	-	
93-76-5	Trichlorophenoxyacetic Acid, 2,4,5-	1	0.1	1	-		-		0.01	I	-	
93-72-1	Trichlorophenoxypropionic acid, -2,4,5	1	0.1	1	-		-		0.008	I	-	
96-18-4	Trichloropropane, 1,2,3-	1	-	1	30	I	-		0.004	I	0.0003	I
95-63-6	Trimethylbenzene, 1,2,4-	1	-	1	-		-		-		0.007	P

CAS Number[1]	Compound	GIABS	ABS	RBA	Ingestion SF (mg/kg day)$^{-1}$	Ref[2]	Inhalation Unit Risk ($\mu g/m^3$)$^{-1}$	Ref[2]	Chronic RfD (mg/kg day)	Ref[2]	Chronic RfC (mg/m^3)	Ref[2]
108-67-8	Trimethylbenzene, 1,3,5-	1	-	1	-		-		0.01	X	-	
688-73-3	Tri-n-butyltin	1	-	1	-		-		0.0003	A	-	
99-35-4	Trinitrobenzene, 1,3,5-	1	0.019	1	-		-		0.03	I	-	
118-96-7	Trinitrotoluene, 2,4,6-	1	0.032	1	0.03	I	-		0.0005	I	-	
7440-62-2	Vanadium and Compounds	0.026	-	1	-		-		0.00504	X	0.0001	A
108-05-4	Vinyl Acetate	1	-	1	-		-		1	H	0.2	I
75-01-4	Vinyl Chloride	1	-	1	0.72	I	4.4×10^{-6}	I	0.003	I	0.1	I
1330-20-7	Xylenes	1	-	1	-		-		0.2	I	0.1	I
7440-66-6	Zinc and Compounds	1	-	1	-		-		0.3	I	-	

[1] "CAS Number" means the Chemical Abstract Service (CAS) registry number uniquely assigned to chemicals by the American Chemical Society and recorded in the CAS Registry System

[2] Reference source for data; I= Integrated Risk Information System; P= Provisional Peer Reviewed Toxicity Values; A= Agency for Toxic Substances and Disease Registry; C= California Environmental Protection Agency (EPA); X=Appendix Provisional Peer Reviewed Toxicity Values Screen; H=EPA's Health Effects Assessment Summary Tables; J=New Jersey; S=Surrogate Compound; W= EPA Office of Water

[3] Polycyclic aromatic hydrocarbons (PAH) ingestion slope factors are determined using Benzo[a]pyrene and Toxicity Equivalence Factors (TEFs) as described in the Risk Assessment Procedures Manual

[4] Pyrene is a toxicity surrogate for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene

[5] Cyanide expressed as free, or physiologically available cyanide; The IRIS RfC for "Hydrogen Cyanide" is used as a surrogate for "Cyanide (CN-)".

[6] 1,2-dichlorobenzene is a toxicity surrogate for 1,3-dichlorobenzene

[7] Diethylphthalate is a toxicity surrogate for dimethylphthalate

[8] Lead cleanup levels are based on land use; for residential land use, the soil cleanup level is 400 mg/kg

[9] Elemental mercury is a toxicity surrogate for mercuric chloride

[10] Toxicity is given in EPA's Health Effects Support Document for Perfluorooctane Sulfonate (PFOS) 2016.

[11] Toxicity is given in EPA's Health Effects Support Document for Perfluorooctanoic Acid (PFOA) 2016.

[12] The cleanup level in 18 AAC 75.341(c) Table B1 is for 2,3,7,8-Tetrachlorordibenzo-p-Dioxin (TCDD) only; all cleanup levels for polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran congeners must be determined on a site-specific basis.

[13] The IRIS oral RfD for 2,4-Dinitrotoluene is used as a surrogate for 2-Amino-4,6-Dinitrotoluene and 4-Amino-2,6-Dinitrotoluene.

[14] For unrestricted land use, the cleanup level for polychlorinated biphenyls (PCBs) is 1 mg/kg.

Table 7 Organic and Inorganic Chemical Specific Parameters

CAS Number[1]	Compound	VOC	D_a (cm^2/s)	D_w (cm^2/s)	Solubility (mg/L)	K_d (cm^3/g)	K_{oc} (cm^3/g)	H' (unitless)	MW (g/mol)	FA	Kp (cm/h)	Melting Point (°C)
83-32-9	Acenaphthene	Yes	0.0506143	8.33×10^{-6}	3.9	5.027	5027	0.00752248569092	154.21	1	0.085	93.4
208-96-8	Acenaphthylene	Yes	0.0449596	6.9822×10^{-6}	16.1	5.027	5027	0.00466067048242	152.2	1	0.0911	92.5
67-64-1	Acetone	Yes	0.1059215	0.0000115	1000000	0.002364	2.364	0.00143090760425	58.081	1	0.000512	-98.3
309-00-2	Aldrin	Yes	0.0228116	5.8402×10^{-6}	0.017	82.02	82020	0.00179885527391	364.92	1	-	240
7790-98-9	Ammonium Perchlorate	No	-	-	245000	0	-	-	117.49	1	0.001	-
120-12-7	Anthracene	Yes	0.0389732	7.8523×10^{-6}	0.0434	16.36	16360	0.00227309893704	178.24	1	0.142	215
7440-36-0	Antimony (metallic)	No	-	-	-	45	-	-	124.77	1	0.001	630.628
7440-38-2	Arsenic, Inorganic	No	-	-	-	29	-	-	77.946	1	0.001	270
7440-39-3	Barium	No	-	-	-	41	-	-	139.36	1	0.001	727
56-55-3	Benz[a]anthracene	Yes	0.0261138	6.7495×10^{-6}	0.0094	176.9	176900	0.00049059689288	228.3	1	-	84
100-52-7	Benzaldehyde	Yes	0.074393	9.4627×10^{-6}	6950	0.01109	11.09	0.00109157808667	106.13	1	0.00383	-26
71-43-2	Benzene	Yes	0.089534	0.0000103	1790	0.1458	145.8	0.22690106295993	78.115	1	0.0149	5.5
50-32-8	Benzo[a]pyrene	No	0.0475831	5.5597×10^{-6}	0.00162	587.4	587400	0.000018683565	252.32	1	-	176.5
205-99-2	Benzo[b]fluoranthene	No	0.0475831	5.5597×10^{-6}	0.0015	599.4	599400	0.00002686017988	252.32	1	-	168
191-24-2	Benzo[g,h,i]perylene	No	0.0447842	5.2327×10^{-6}	0.00026	1951	1951000	0.00001353229762	276.34	0.7	-	278
207-08-9	Benzo[k]fluoranthene	No	0.0475831	5.5597×10^{-6}	0.0008	587.4	587400	0.00002387571545	252.32	0.9	-	217
65-85-0	Benzoic Acid	No	0.0701939	9.7868×10^{-6}	3400	0.0006	0.6	$1.5576451349141 \times 10^{-6}$	122.12	1	0.00565	122.4
100-51-6	Benzyl Alcohol	No	0.0731186	9.3665×10^{-6}	42900	0.02146	21.46	0.00001377759607	108.14	1	0.00209	-15.2
7440-41-7	Beryllium and compounds	No	-	-	-	790	-	-	11.028	1	0.001	986
111-44-4	Bis(2-chloroethyl)ether	Yes	0.0567192	8.707×10^{-6}	17200	0.03221	32.21	0.00069501226492	143.01	1	0.00178	-51.9
117-81-7	Bis(2-ethylhexyl)phthalate	No	0.0173403	4.1807×10^{-6}	0.27	119.6	119600	0.00001103843008	390.57	0.8	-	-55
108-86-1	Bromobenzene	Yes	0.0537132	9.3004×10^{-6}	446	0.2339	233.9	0.10098119378577	157.01	1	0.02	-30.6
75-27-4	Bromodichloromethane	Yes	0.0562629	0.0000107	3032	0.03182	31.82	0.08667211774325	163.83	1	0.00402	-57
75-25-2	Bromoform	Yes	0.0357324	0.0000104	3100	0.03182	31.82	0.02187244480784	252.73	1	0.00235	8
74-83-9	Bromomethane	Yes	0.1004976	0.0000135	15200	0.01322	13.22	0.30008176614881	94.939	1	0.00284	-93.7
106-99-0	Butadiene, 1,3-	Yes	0.1003488	0.0000103	735	0.0396	39.6	3.00899427636958	54.092	1	0.0164	-108.9
71-36-3	Butanol, N-	Yes	0.0900387	0.0000101	63200	0.003471	3.471	0.00036017988552	74.124	1	0.00231	-89.8
85-68-7	Butyl Benzyl Phthalate	No	0.0208319	5.1733×10^{-6}	2.69	7.155	7155	0.00005151267375	312.37	0.9	0.0385	-35
104-51-8	Butylbenzene, n-	Yes	0.0527732	7.3335×10^{-6}	11.8	1.482	1482	0.6500408830744	134.22	1	-	-87.9
135-98-8	Butylbenzene, sec-	Yes	0.0527928	7.3371×10^{-6}	17.6	1.331	1331	0.71954210956663	134.22	1	-	-82.7
98-06-6	Butylbenzene, tert-	Yes	0.0529525	7.3662×10^{-6}	29.5	1.001	1001	0.53965658217498	134.22	1	0.149	-57.8
7440-43-9	Cadmium	No	-	-	-	75	-	-	112.4	1	0.001	321
75-15-0	Carbon Disulfide	Yes	0.1064373	0.000013	2160	0.02173	21.73	0.58871627146361	76.139	1	0.0114	-111.5
56-23-5	Carbon Tetrachloride	Yes	0.0571435	9.7849×10^{-6}	793	0.04389	43.89	1.12837285363859	153.82	1	0.0163	-23
12789-03-6	Chlordane	Yes	0.021493	5.4477×10^{-6}	0.056	67.54	67540	0.00198691741618	409.78	0.7	0.107	132.97
143-50-0	Chlordecone (Kepone)	No	0.019647	4.9081×10^{-6}	2.7	17.5	17500	$2.1995094031071 \times 10^{-6}$	490.64	0.8	0.0109	350
106-47-8	Chloroaniline, p-	No	0.0703847	0.0000103	3900	0.1127	112.7	0.00004742436631	127.57	1	0.00496	72.5
108-90-7	Chlorobenzene	Yes	0.0721306	9.4765×10^{-6}	498	0.2339	233.9	0.12714636140637	112.56	1	0.0282	-45.2
67-66-3	Chloroform	Yes	0.0769197	0.0000109	7950	0.03182	31.82	0.1500408830744	119.38	1	0.00683	-63.6
74-87-3	Chloromethane	Yes	0.1239651	0.0000136	5320	0.01322	13.22	0.36058871627146	50.488	1	0.00328	-97.7
91-58-7	Chloronaphthalene, Beta-	Yes	0.0446914	7.7301×10^{-6}	11.7	2.478	2478	0.0130825838103	162.62	1	0.0749	61

CAS Number[1]	Compound	VOC	D_a (cm^2/s)	D_w (cm^2/s)	Solubility (mg/L)	K_d (cm^3/g)	K_{oc} (cm^3/g)	H' (unitless)	MW (g/mol)	FA	Kp (cm/h)	Melting Point (°C)
95-57-8	Chlorophenol, 2-	Yes	0.0661175	9.4784×10^{-6}	11300	0.388	388	0.00045789043336	128.56	1	0.00799	9.8
16065-83-1	Chromium(III), Insoluble Salts	No	-	-	-	1800000	-	-	52	1	0.001	-
18540-29-9	Chromium(VI)	No	-	-	1690000	19	-	-	52	1	0.002	-
218-01-9	Chrysene	No	0.0261138	6.7495×10^{-6}	0.002	180.5	180500	0.00021381847914	228.3	1	-	258.2
7440-50-8	Copper	No	-	-	-	35	-	-	63.546	1	0.001	1084.62
108-39-4	Cresol, m-	No	0.0728721	9.3232×10^{-6}	22700	0.3004	300.4	0.00003499591169	108.14	1	0.00777	11.8
95-48-7	Cresol, o-	No	0.072835	9.3168×10^{-6}	25900	0.3065	306.5	0.00004905968928	108.14	1	0.00766	29.8
106-44-5	Cresol, p-	No	0.0723938	9.2397×10^{-6}	21500	0.3004	300.4	0.0000408830744	108.14	1	0.00754	35.5
98-82-8	Cumene	Yes	0.0603044	7.8566×10^{-6}	61.3	0.6978	697.8	0.47015535568274	120.2	1	0.0897	-96
57-12-5	Cyanide (CN-)	Yes	0.2109549	0.0000246	95400	9.9	-	0.00415	26.018	1	0.001	-
110-82-7	Cyclohexane	Yes	0.0799729	9.1077×10^{-6}	55	0.1458	145.8	6.13246116107931	84.163	1	0.102	6.6
72-54-8	DDD	No	0.0406077	4.7447×10^{-6}	0.09	117.5	117500	0.00026982829108	320.05	0.8	0.251	109.5
72-55-9	DDE, p,p'-	Yes	0.0229959	5.8592×10^{-6}	0.04	117.5	117500	0.00170073589533	318.03	0.8	-	89
50-29-3	DDT	No	0.037933	4.4322×10^{-6}	0.0055	168.6	168600	0.00034014717906	354.49	0.7	-	108.5
53-70-3	Dibenz[a,h]anthracene	No	0.0445672	5.2073×10^{-6}	0.00249	1912	1912000	$5.7645134914145 \times 10^{-6}$	278.36	0.6	-	269.5
132-64-9	Dibenzofuran	Yes	0.0650663	7.3773×10^{-6}	3.1	9.161	9161	0.00870809484873	168.2	1	0.0975	86.5
124-48-1	Dibromochloromethane	Yes	0.0366356	0.0000106	2700	0.03182	31.82	0.03201144726083	208.28	1	0.00289	-20
106-93-4	Dibromoethane, 1,2-	Yes	0.0430348	0.0000104	3910	0.0396	39.6	0.02657399836467	187.86	1	0.00278	9.9
74-95-3	Dibromomethane (Methylene Bromide)	Yes	0.0551373	0.0000119	11900	0.02173	21.73	0.03360588716271	173.84	1	0.00223	-52.5
84-74-2	Dibutyl Phthalate	No	0.0214362	5.3255×10^{-6}	11.2	1.157	1157	0.00007399836467	278.35	0.9	0.042	-35
95-50-1	Dichlorobenzene, 1,2-	Yes	0.0561703	8.9213×10^{-6}	156	0.3829	382.9	0.07849550286181	147	1	0.0446	-16.7
541-73-1	Dichlorobenzene, 1,3-	Yes	0.0558361	8.8494×10^{-6}	125	0.3753	375.3	0.10752248569092	147	1	0.052	-24.8
106-46-7	Dichlorobenzene, 1,4-	Yes	0.0550429	8.6797×10^{-6}	81.3	0.3753	375.3	0.09852820932134	147	1	0.0453	52.09
91-94-1	Dichlorobenzidine, 3,3'-	No	0.0474815	5.5478×10^{-6}	3.1	3.19	3190	$1.1610793131643 \times 10^{-9}$	253.13	1	0.0128	132
75-71-8	Dichlorodifluoromethane	Yes	0.0760293	0.0000108	280	0.04389	43.89	14.022894521668	120.91	1	0.00895	-158
75-34-3	Dichloroethane, 1,1-	Yes	0.0836446	0.0000106	5040	0.03182	31.82	0.22976287816843	98.96	1	0.00675	-96.9
107-06-2	Dichloroethane, 1,2-	Yes	0.0857221	0.000011	8600	0.0396	39.6	0.04824202780049	98.96	1	0.0042	-35.5
75-35-4	Dichloroethylene, 1,1-	Yes	0.0863107	0.000011	2420	0.03182	31.82	1.0670482420278	96.944	1	0.0117	-122.5
156-59-2	Dichloroethylene, 1,2-cis-	Yes	0.0884056	0.0000113	6410	0.0396	39.6	0.16680294358135	96.944	1	0.011	-57
156-60-5	Dichloroethylene, 1,2-trans-	Yes	0.0876094	0.0000112	4520	0.0396	39.6	0.38348323793949	96.944	1	0.011	-49.8
120-83-2	Dichlorophenol, 2,4-	No	0.0485768	8.6787×10^{-6}	5550	0.147	147	0.0001753883892	163	1	0.0206	45
94-75-7	Dichlorophenoxy Acetic Acid, 2,4-	No	0.0279179	7.3445×10^{-6}	677	0.02963	29.63	$1.4472608340147 \times 10^{-6}$	221.04	1	0.00664	140.5
78-87-5	Dichloropropane, 1,2-	Yes	0.0733402	9.7252×10^{-6}	2800	0.0607	60.7	0.11529026982829	112.99	1	0.00753	-100
542-75-6	Dichloropropene, 1,3-	Yes	0.0762725	0.0000101	2800	0.07217	72.17	0.14513491414554	110.97	1	0.00834	-50
60-57-1	Dieldrin	No	0.0232865	6.0062×10^{-6}	0.195	20.09	20090	0.00040883074407	380.91	0.8	0.0326	175.5
84-66-2	Diethyl Phthalate	No	0.0260741	6.7227×10^{-6}	1080	0.1049	104.9	0.00002493867538	222.24	1	0.0036	-40.5
105-67-9	Dimethylphenol, 2,4-	No	0.0622451	8.314×10^{-6}	7870	0.4918	491.8	0.00003887980376	122.17	1	0.0109	24.5
131-11-3	Dimethylphthalate	No	0.0299117	7.1412×10^{-6}	4000	0.03159	31.59	$8.0539656582175 \times 10^{-6}$	194.19	1	0.00147	5.5
528-29-0	Dinitrobenzene, 1,2-	No	0.0447176	8.2538×10^{-6}	133	0.3588	358.8	$2.1790678659035 \times 10^{-5}$	168.11	1	0.00237	118.5
99-65-0	Dinitrobenzene, 1,3-	No	0.0484987	9.2109×10^{-6}	533	0.3516	351.6	$2.0032706459525 \times 10^{-5}$	168.11	1	0.00174	90
100-25-4	Dinitrobenzene, 1,4-	No	0.0491668	9.3849×10^{-6}	69	0.3516	351.6	$3.4300899427637 \times 10^{-5}$	168.11	1	0.00167	174
51-28-5	Dinitrophenol, 2,4-	No	0.0406699	9.0756×10^{-6}	2790	0.4608	460.8	$3.5159443990188 \times 10^{-6}$	184.11	1	0.00187	115.5
121-14-2	Dinitrotoluene, 2,4-	No	0.0375115	7.8982×10^{-6}	200	0.5756	575.6	$2.2076860179885 \times 10^{-5}$	182.14	1	0.00308	71

CAS Number[1]	Compound	VOC	D_a (cm^2/s)	D_w (cm^2/s)	Solubility (mg/L)	K_d (cm^3/g)	K_{oc} (cm^3/g)	H' (unitless)	MW (g/mol)	FA	K_p (cm/h)	Melting Point (°C)
606-20-2	Dinitrotoluene, 2,6-	No	0.0370256	7.7629×10^{-6}	182	0.5874	587.4	0.00003053965658	182.14	1	0.0037	66
35572-78-2	Dinitrotoluene, 2-Amino-4,6-	No	0.0560905	6.5537×10^{-6}	1220	0.283	283	$1.3368765331152 \times 10^{-5}$	197.15	1	0.00204	174.5
19406-51-0	Dinitrotoluene, 4-Amino-2,6-	No	0.0560905	6.5537×10^{-6}	1220	0.283	283	$1.3368765331152 \times 10^{-5}$	197.15	1	0.00204	171
123-91-1	Dioxane, 1,4-	Yes	0.0873739	0.0000105	1000000	0.002633	2.633	0.00019623875715	88.107	1	0.000332	11.8
122-39-4	Diphenylamine	No	0.0417056	7.628×10^{-6}	53	0.8258	825.8	0.00010997547015	169.23	1	0.0373	52.9
115-29-7	Endosulfan	Yes	0.0224845	5.7629×10^{-6}	0.325	6.761	6761	0.00265739983646	406.93	0.9	0.00286	106
72-20-8	Endrin	No	0.0361581	4.2248×10^{-6}	0.25	20.09	20090	0.00026001635322	380.91	0.8	0.0326	226
75-00-3	Ethyl Chloride	Yes	0.1037597	0.0000116	6710	0.02173	21.73	0.45380212591986	64.515	1	0.00607	-138.7
100-41-4	Ethylbenzene	Yes	0.0684652	8.4558×10^{-6}	169	0.4461	446.1	0.3221586263287	106.17	1	0.0493	-94.9
107-21-1	Ethylene Glycol	No	0.116925	0.0000136	1000000	0.001	1	2.453×10^{-6}	62.069	1	0.0000877	-13
206-44-0	Fluoranthene	No	0.0275957	7.1827×10^{-6}	0.26	55.45	55450	0.00036222403924	202.26	1	-	107.8
86-73-7	Fluorene	Yes	0.0439743	7.889×10^{-6}	1.69	9.16	9160	0.00393295175797	166.22	1	0.11	114.8
50-00-0	Formaldehyde	Yes	0.1670871	0.0000174	400000	0.001	1	0.00001377759607	30.026	1	0.00182	-92
76-44-8	Heptachlor	Yes	0.0223441	5.6959×10^{-6}	0.18	41.26	41260	0.01201962387571	373.32	0.8	0.143	95.5
1024-57-3	Heptachlor Epoxide	Yes	0.0240006	6.2475×10^{-6}	0.2	10.11	10110	0.00085854456255	389.32	0.8	0.0209	160
118-74-1	Hexachlorobenzene	Yes	0.0289745	7.8497×10^{-6}	0.0062	6.195	6195	0.06950122649223	284.78	0.9	-	231.8
87-68-3	Hexachlorobutadiene	Yes	0.0267445	7.0264×10^{-6}	3.2	0.8452	845.2	0.42109566639411	260.76	0.9	0.081	-21
319-84-6	Hexachlorocyclohexane, Alpha-	No	0.043284	5.0574×10^{-6}	2	2.807	2807	0.00027391659852	290.83	0.9	0.0206	112.5
319-85-7	Hexachlorocyclohexane, Beta-	No	0.0276672	7.3955×10^{-6}	0.24	2.807	2807	0.00001798855273	290.83	0.9	0.0206	112.5
58-89-9	Hexachlorocyclohexane, Gamma- (Lindane)	No	0.043284	5.0574×10^{-6}	7.3	2.807	2807	0.00021013900245	290.83	0.9	0.0206	112.5
77-47-4	Hexachlorocyclopentadiene	Yes	0.0272382	7.217×10^{-6}	1.8	1.404	1404	1.10384300899428	272.77	0.9	0.103	-9
67-72-1	Hexachloroethane	Yes	0.0320938	8.8904×10^{-6}	50	0.1968	196.8	0.15903515944399	236.74	1	0.0415	187
121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	No	0.0311541	8.4989×10^{-6}	59.7	0.08907	89.07	$8.2174979558462 \times 10^{-20}$	222.12	1	0.000336	205.5
110-54-3	Hexane, N-	Yes	0.0731078	8.1657×10^{-6}	9.5	0.1315	131.5	73.5895339329518	86.178	1	0.201	-95.3
591-78-6	Hexanone, 2-	Yes	0.0703564	8.4404×10^{-6}	17200	0.01498	14.98	0.00381030253475	100.16	1	0.00355	-55.5
302-01-2	Hydrazine[3]	Yes	0.1733034	0.000019	1000000	0.002	2	0.000025	32.045	1	0.0000436	2
193-39-5	Indeno[1,2,3-cd]pyrene	No	0.0447842	5.2327×10^{-6}	0.00019	1951	1951000	0.00001422730989	276.34	0.6	-	163.6
78-59-1	Isophorone	No	0.0525048	7.5296×10^{-6}	12000	0.06515	65.15	0.00027146361406	138.21	1	0.00354	-8.1
67-63-0	Isopropanol	Yes	0.1032261	0.0000112	1000000	0.00153	1.53	0.00033115290269	60.097	1	0.000778	-89.5
7439-92-1	Lead and Compounds	No	-	-	-	900	-	-	207.2	1	0.0001	327.5
7487-94-7	Mercuric Chloride	No	-	-	69000	52	-	-	271.5	1	0.001	277
7439-97-6	Mercury (elemental)	Yes	0.0307	6.3×10^{-6}	0.06	52	-	0.352	200.59	1	0.001	-38.8
67-56-1	Methanol	Yes	0.1582741	0.0000165	1000000	0.001	1	0.00018601798855	32.042	1	0.000319	-97.6
72-43-5	Methoxychlor	No	0.0220849	5.5926×10^{-6}	0.1	26.89	26890	$8.2992641046606 \times 10^{-6}$	345.66	0.8	0.0428	87
78-93-3	Methyl Ethyl Ketone (2-Butanone)	Yes	0.0914462	0.0000102	223000	0.00451	4.51	0.00232624693376	72.108	1	0.000962	-86.6
108-10-1	Methyl Isobutyl Ketone (4-methyl-2-pentanone)	Yes	0.0697797	8.3477×10^{-6}	19000	0.0126	12.6	0.00564186426819	100.16	1	0.00319	-84
22967-92-6	Methyl Mercury[4]	No	-	-	-	7000	-	-	216.6326	1	0.001	-
1634-04-4	Methyl tert-Butyl Ether (MTBE)	Yes	0.0752672	8.5905×10^{-6}	51000	0.01156	11.56	0.02399836467702	88.151	1	0.00211	-108.6
75-09-2	Methylene Chloride	Yes	0.0999362	0.0000125	13000	0.02173	21.73	0.13286999182338	84.933	1	0.00354	-95.1
90-12-0	Methylnaphthalene, 1-	Yes	0.0527705	7.8477×10^{-6}	25.8	2.528	2528	0.02101390024529	142.2	1	0.0931	34
91-57-6	Methylnaphthalene, 2-	Yes	0.0524319	7.7811×10^{-6}	24.6	2.478	2478	0.02117743254292	142.2	1	0.0917	34.4
91-20-3	Naphthalene	Yes	0.0604994	8.377×10^{-6}	31	1.544	1544	0.01798855273916	128.18	1	0.0466	80.2
7440-02-0	Nickel Soluble Salts	No	-	-	-	65	-	-	58.71	1	0.0002	1455

Sulfonate X CCR

CAS Number[1]	Compound	VOC	D_a (cm^2/s)	D_w (cm^2/s)	Solubility (mg/L)	K_d (cm^3/g)	K_{oc} (cm^3/g)	H' (unitless)	MW (g/mol)	FA	Kp (cm/h)	Melting Point (°C)
98-95-3	Nitrobenzene	Yes	0.068054	9.4495×10^{-6}	2090	0.2264	226.4	0.00098119378577	123.11	1	0.00541	5.7
55-63-0	Nitroglycerin	No	0.029015	7.7428×10^{-6}	1380	0.1158	115.8	$3.5404742436631 \times 10^{-8}$	227.09	1	0.000994	13.5
556-88-7	Nitroguanidine	No	0.0996937	0.0000142	4400	0.02065	20.65	$1.8192968111202 \times 10^{-14}$	104.07	1	0.000105	239
62-75-9	Nitrosodimethylamine, N-	Yes	0.0987674	0.0000115	1000000	0.02279	22.79	0.00007440719542	74.083	1	0.000251	-39.07
621-64-7	Nitroso-di-N-propylamine, N-	No	0.0564399	7.758×10^{-6}	13000	0.2754	275.4	0.00021995094031	130.19	1	0.00233	6.81
86-30-6	Nitrosodiphenylamine, N-	No	0.0558866	6.5299×10^{-6}	35	2.632	2632	0.00004946852003	198.23	1	0.0145	66.5
99-08-1	Nitrotoluene, m-	No	0.058686	8.6541×10^{-6}	500	0.3632	363.2	0.00038021259198	137.14	1	0.0113	15.5
88-72-2	Nitrotoluene, o-	Yes	0.0587535	8.6675×10^{-6}	650	0.3706	370.6	0.00051103843008	137.14	1	0.00899	-10
99-99-0	Nitrotoluene, p-	No	0.0574432	8.4083×10^{-6}	442	0.3632	363.2	0.00023017170891	137.14	1	0.01	51.6
2691-41-0	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	No	0.0427631	4.9965×10^{-6}	5	0.5316	531.6	$3.5445625511038 \times 10^{-8}$	296.16	1	0.0000436	286
117-84-0	Octyl Phthalate, di-N-	No	0.0355594	4.1548×10^{-6}	0.022	140.8	140800	0.00010506950122	390.57	0	-	-4
87-86-5	Pentachlorophenol	No	0.0295197	8.0121×10^{-6}	14	0.592	592	$1.0016353229762 \times 10^{-6}$	266.34	0.9	0.127	174
78-11-5	Pentaerythritol tetranitrate (PETN)	No	0.025756	6.7697×10^{-6}	43	0.6479	647.9	$5.3965658217498 \times 10^{-8}$	316.14	1	0.00101	140.5
1763-23-1	Perfluorooctane Sulphonic Acid (PFOS)[5]	No	0.0207478	5.2533×10^{-6}	680	0.3715	371.5	-	500.13	0	-	51.9
335-67-1	Perfluorooctanoic Acid (PFOA)[5]	No	0.02257	5.7947×10^{-6}	9500	0.1148	114.8	-	414.07	0	-	55
85-01-8	Phenanthrene	Yes	0.0344784	6.6897×10^{-6}	1.15	16.69	16690	0.00172935404742	178.24	1	0.144	99.2
108-95-2	Phenol	No	0.0833983	0.0000103	82800	0.1872	187.2	0.00001361406377	94.114	1	0.00434	40.9
7723-14-0	Phosphorus, White	Yes	0.2193655	0.0000277	3	3.5	1122	0.086	123.895	1	0.001	44.15
1336-36-3	Polychlorinated Biphenyls	Yes	0.0243397	6.2671×10^{-6}	0.7	78.1	78100	0.016966475878 98	291.99	0.7	-	122.32
103-65-1	Propyl benzene	Yes	0.0601558	7.831×10^{-6}	52.2	0.8131	813.1	0.42927228127555	120.2	1	0.0939	-99.5
129-00-0	Pyrene	Yes	0.0277873	7.2479×10^{-6}	0.135	54.34	54340	0.00048650858544	202.26	1	0.201	151.2
7782-49-2	Selenium	No	-	-	-	5	-	-	78.96	1	0.001	221
7440-22-4	Silver	No	-	-	-	8.3	-	-	107.87	1	0.0006	961.78
100-42-5	Styrene	Yes	0.071114	8.7838×10^{-6}	310	0.4461	446.1	0.11242845461978	104.15	1	0.0372	-31
1746-01-6	TCDD, 2,3,7,8-	Yes	0.0470278	6.7568×10^{-6}	0.0002	249.1	249100	0.00204415372035	321.98	0.5	-	305
630-20-6	Tetrachloroethane, 1,1,1,2-	Yes	0.0481761	9.0977×10^{-6}	1070	0.08603	86.03	0.10220768601798	167.85	1	0.0159	-70.2
79-34-5	Tetrachloroethane, 1,1,2,2-	Yes	0.0489206	9.2902×10^{-6}	2830	0.09494	94.94	0.01500408830744	167.85	1	0.00694	-43.8
127-18-4	Tetrachloroethylene	Yes	0.0504664	9.4551×10^{-6}	206	0.09494	94.94	0.72363041700735	165.83	1	0.0334	-22.3
479-45-8	Tetryl (Trinitrophenylmethylnitramine)	No	0.0255626	6.6672×10^{-6}	74	4.605	4605	$1.107931316435 \times 10^{-7}$	287.15	1	0.000474	131.5
7440-28-0	Thallium (Soluble Salts)	No	-	-	-	71	-	-	205.38	1	0.001	303.5
108-88-3	Toluene	Yes	0.0778039	9.2045×10^{-6}	526	0.2339	233.9	0.27146361406377	92.142	1	0.0311	-94.9
8001-35-2	Toxaphene	No	0.032439	3.7902×10^{-6}	0.55	77.2	77200	0.00024529844644	448.26	0.8	-	65
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2-	Yes	0.0375658	8.592×10^{-6}	170	0.1968	196.8	21.5044971381848	187.38	1	0.0175	-35
87-61-6	Trichlorobenzene, 1,2,3-	Yes	0.03953	8.3836×10^{-6}	18	1.383	1383	0.05110384300899	181.45	1	0.0738	53.5
120-82-1	Trichlorobenzene, 1,2,4-	Yes	0.0395992	8.4033×10^{-6}	49	1.356	1356	0.05805396565821	181.45	1	0.0705	17
71-55-6	Trichloroethane, 1,1,1-	Yes	0.0648174	9.599×10^{-6}	1290	0.04389	43.89	0.70318887980376	133.41	1	0.0126	-30.4
79-00-5	Trichloroethane, 1,1,2-	Yes	0.0668904	0.00001	4590	0.0607	60.7	0.03368765331152	133.41	1	0.00504	-36.6
79-01-6	Trichloroethylene	Yes	0.0686618	0.0000102	1280	0.0607	60.7	0.40269828291087	131.39	1	0.0116	-84.7
75-69-4	Trichlorofluoromethane	Yes	0.065356	0.00001	1100	0.04389	43.89	3.96565821749796	137.37	1	0.0127	-111.1
95-95-4	Trichlorophenol, 2,4,5-	No	0.0313938	8.0893×10^{-6}	1200	1.597	1597	0.00006623058053	197.45	1	0.0362	69
88-06-2	Trichlorophenol, 2,4,6-	No	0.0313948	8.0896×10^{-6}	800	0.381	381	0.00010629599345	197.45	1	0.0346	69
93-76-5	Trichlorophenoxyacetic Acid, 2,4,5-	No	0.0288853	7.7627×10^{-6}	278	0.107	107	$3.5486508585445 \times 10^{-7}$	255.49	0.9	0.00914	153
93-72-1	Trichlorophenoxypropionic acid, -2,4,5	No	0.0233585	5.9194×10^{-6}	71	0.1753	175.3	$3.7040065412919 \times 10^{-7}$	269.51	0.9	0.0161	181.6

CAS Number[1]	Compound	VOC	D_a (cm^2/s)	D_w (cm^2/s)	Solubility (mg/L)	K_d (cm^3/g)	K_{oc} (cm^3/g)	H' (unitless)	MW (g/mol)	FA	Kp (cm/h)	Melting Point (°C)
96-18-4	Trichloropropane, 1,2,3-	Yes	0.0574661	9.2411×10^{-6}	1750	0.1158	115.8	0.01402289452166	147.43	1	0.00752	-14.7
95-63-6	Trimethylbenzene, 1,2,4-	Yes	0.0606754	7.9209×10^{-6}	57	0.6143	614.3	0.25183973834832	120.2	1	0.0857	-43.8
108-67-8	Trimethylbenzene, 1,3,5-	Yes	0.0602254	7.843×10^{-6}	48.2	0.6021	602.1	0.3585445625511	120.2	1	0.0621	-44.7
688-73-3	Tri-n-butyltin	Yes	0.0214738	5.351×10^{-6}	0.0073	8.091	8091	62.142273098937	291.05	0.9	0.0193	28.89
99-35-4	Trinitrobenzene, 1,3,5-	No	0.0289685	7.6882×10^{-6}	278	1.683	1683	$2.6573998364677 \times 10^{-7}$	213.11	1	0.000607	121.5
118-96-7	Trinitrotoluene, 2,4,6-	No	0.0295093	7.9182×10^{-6}	115	2.812	2812	$8.5036794766966 \times 10^{-7}$	227.13	1	0.000963	80.1
7440-62-2	Vanadium and Compounds	No	-	-	-	1000	-	-	50.94	1	0.001	1910
108-05-4	Vinyl Acetate	Yes	0.0849016	0.00001	20000	0.005583	5.583	0.02089125102207	86.091	1	0.00157	-93.2
75-01-4	Vinyl Chloride	Yes	0.1071202	0.000012	8800	0.02173	21.73	1.13654946852003	62.499	1	0.00838	-153.7
1330-20-7	Xylenes	Yes	0.0685148	8.4641×10^{-6}	106	0.3829	382.9	0.2710547833197	106.17	1	0.05	-25.2
7440-66-6	Zinc and Compounds	No	-	-	-	62	-	-	65.37	1	0.0006	419.5

Sources for the parameters listed in this table were obtained using the chemical parameter hierarchy found in Section 1.0 of this document.

[1] "CAS Number" means the Chemical Abstract Service (CAS) registry number uniquely assigned to chemicals by the American Chemical Society and recorded in the CAS Registry System

[2] "c" means carcinogenic, "nc" means noncarcinogenic, and "m" means mutagenic

[3] Hydrazine Kd value is taken from the National Institute of Health's Toxic Substances Databank

[4] Methyl mercury Kd value is taken from U.S. EPA. 1997 Mercury Study Report to Congress. EPA-452/R-97-005. Office of Air Quality Planning and Standards and Office of Research and Development. December

[5] PFOS and PFOA Koc values are taken from Higgins C and Luthy R. (2006) Sorption of Perfluorinated Surfactants on Sediments. Environ Sci Technol. 40(23):7251–7256.

Appendix B – Table 8 - Standard Default Factors for Non-Petroleum Organic and Inorganic Contaminants

Symbol	Definition (units)	Default	Reference(s)
A	Dispersion constant (unitless)	Arctic Zone = 7.1414 Under 40" Zone = 16.2302 Over 40" Zone = 14.2253	U.S. EPA 2002 Harding Lawson Associates
AF	Attenuation factor (unitless)	4	Professional judgment
$AF_{0\text{-}2}$	Skin adherence factor – age segment 0 – 2 years old (mg/cm^2)	0.2	U.S. EPA 2004
$AF_{2\text{-}6}$	Skin adherence factor – age segment 2 – 6 years old (mg/cm^2)	0.2	U.S. EPA 2004
$AF_{6\text{-}16}$	Skin adherence factor – age segment 6 – 16 years old (mg/cm^2)	0.07	U.S. EPA 2004
$AF_{16\text{-}26}$	Skin adherence factor – age segment 16 – 26 years old (mg/cm^2)	0.07	U.S. EPA 2004
AF_{iw}	Skin adherence factor – indoor worker (mg/cm^2)	0.12	U.S. EPA 2011
AF_{ow}	Skin adherence factor – indoor worker (mg/cm^2)	0.12	U.S. EPA 2011
AF_{ressa}	Skin adherence factor – resident soil adult (mg/cm^2)	0.07	U.S. EPA 2004
AF_{ressc}	Skin adherence factor – resident soil child (mg/cm^2)	0.2	U.S. EPA 2004
	Areal extent of the site or contamination (acres)	0.5	U.S. EPA 2002
AT_{iw}	Averaging time – indoor worker (days)	$365 \times ED_{iws} = 9125$	U.S. EPA 1989
AT_{ow}	Averaging time – outdoor worker (days)	$365 \times ED_{ows} = 9125$	U.S. EPA 1989
AT_{ress}	Averaging time – resident soil (days)	$365 \times LT = 25550$	U.S. EPA 1989
AT_{ressa}	Averaging time – resident soil adult (days)	$365 \times ED_{ress} = 9490$	U.S. EPA 1989
AT_{ressc}	Averaging time – resident soil child (days)	$365 \times ED_{ressc} = 2190$	U.S. EPA 1989
AT_{resw}	Averaging time – resident groundwater (days)	$365 \times LT = 25550$	U.S. EPA 1989
AT_{reswa}	Averaging time – resident groundwater adult (days)	$365 \times ED_{reswa} = 9490$	U.S. EPA 1989
AT_{reswc}	Averaging time – resident groundwater child (days)	$365 \times ED_{reswc} = 2190$	U.S. EPA 1989
B	Dispersion constant (unitless)	Arctic Zone = 31.1794 Under 40" Zone = 18.7762 Over 40" Zone = 18.8366	U.S. EPA 2002 Harding Lawson Associates
$BW_{0\text{-}2}$	Body weight – age segment 0 – 2 years old (kg)	15	U.S. EPA 2011
$BW_{2\text{-}6}$	Body weight – age segment 2 – 6 years old (kg)	15	U.S. EPA 2011

Symbol	Definition (units)	Default	Reference(s)
BW_{6-16}	Body weight – age segment 6 – 16 years old (kg)	80	U.S. EPA 2011
BW_{16-26}	Body weight – age segment 16 – 26 years old (kg)	80	U.S. EPA 2011
BW_{iw}	Body weight – indoor worker (kg)	80	U.S. EPA 2011
BW_{ow}	Body weight – outdoor worker (kg)	80	U.S. EPA 2011
BW_{ressa}	Body weight –adult (kg)	80	U.S. EPA 2011
BW_{ressc}	Body weight –child (kg)	15	U.S. EPA 2011
BW_{reswa}	Body weight –adult (kg)	80	U.S. EPA 2011
BW_{reswc}	Body weight –child (kg)	15	U.S. EPA 2011
C	Dispersion constant (unitless)	Arctic Zone = 382.6078 Under 40" Zone = 216.108 Over 40" Zone = 218.1845	U.S. EPA 2002 Harding Lawson Associates
d	Mixing zone depth (m)	5.5	U.S. EPA. 2002
d_a	Aquifer thickness (m)	10	U.S. EPA. 2002
d_s	Depth of source (m)	5.5	U.S. EPA. 2002
DAF	Dilution attenuation factor (unitless)	13.2	U.S. EPA. 2002
DF	Dilution factor (unitless)	3.3	Professional judgment
$DFSM_{res-adj}$	Mutagenic dermal contact factor – resident soil age-adjusted (mg/kg)	Arctic Zone = 244720 Under 40" Zone = 330372 Over 40" Zone = 403788	Calculated using the age adjusted intake factors equation
$DFS_{res-adj}$	Dermal contact factor – resident soil age-adjusted (mg/kg)	Arctic Zone = 59080 Under 40" Zone = 79758 Over 40" Zone =97482	Calculated using the age adjusted intake factors equation
$DFWM_{res-adj}$	Mutagenic dermal contact factor – resident groundwater age-adjusted (cm^2 - event/kg)	8191633	Calculated using the age adjusted intake factors equation
$DFW_{res-adj}$	Dermal contact factor – resident groundwater age-adjusted (cm^2 - event/kg)	2610650	Calculated using the age adjusted intake factors equation
ED_{0-2}	Exposure duration – age segment 0 – 2 years old (years)	2	Time Frame
ED_{2-6}	Exposure duration – age segment 2 – 6 years old (years)	4	Time Frame
ED_{6-16}	Exposure duration – age segment 6 – 16 years old (years)	10	Time Frame

Symbol	Definition (units)	Default	Reference(s)
$ED_{16\text{-}26}$	Exposure duration – age segment 16 – 26 years old (years)	10	Time Frame
ED_{iw}	Exposure duration – indoor worker (years)	25	U.S. EPA 1991a
ED_{ow}	Exposure duration – outdoor worker (years)	25	U.S. EPA 1991a
ED_{ress}	Exposure duration – resident soil (years)	26	EPA 2011
ED_{ressa}	Exposure duration – resident soil adult (years)	20	U.S. EPA 1991a
ED_{ressc}	Exposure duration – resident soil child (years)	6	U.S. EPA 1991a
ED_{resw}	Exposure duration – resident groundwater (years)	26	EPA 2011
ED_{reswa}	Exposure duration – resident groundwater adult (years)	20	U.S. EPA 1991a
ED_{reswc}	Exposure duration – resident groundwater child (years)	6	U.S. EPA 1991a
$EF_{0\text{-}2}$	Exposure frequency – age segment 0 – 2 years old (days/year)	Arctic Zone = 200 Under 40" Zone = 270 Over 40" Zone = 330 Migration to Groundwater = 350 Groundwater = 350	Harding Lawson Associates
[illegible]-6	Exposure frequency – age segment 2 – 6 years old (days/year)	Arctic Zone = 200 Under 40" Zone = 270 Over 40" Zone = 330 Migration to Groundwater = 350 Groundwater = 350	Harding Lawson Associates
$EF_{6\text{-}16}$	Exposure frequency – age segment 6 – 16 years old (days/year)	Arctic Zone = 200 Under 40" Zone = 270 Over 40" Zone = 330 Migration to Groundwater = 350 Groundwater = 350	Harding Lawson Associates
$EF_{16\text{-}26}$	Exposure frequency – age segment 16 – 26 years old (days/year)	Arctic Zone = 200 Under 40" Zone = 270 Over 40" Zone = 330 Migration to Groundwater = 350 Groundwater = 350	Harding Lawson Associates
EF_{iws}	Exposure frequency – indoor worker soil (days/year)	Arctic Zone = 200 Under 40" Zone = 250 Over 40" Zone = 250	Harding Lawson Associates

Symbol	Definition (units)	Default	Reference(s)
EF_{ows}	Exposure frequency – outdoor worker soil (days/year)	Arctic Zone = 200 Under 40" Zone = 250 Over 40" Zone = 250	Harding Lawson Associates
EF_{ress}	Exposure frequency - resident soil (days/year)	Arctic Zone = 200 Under 40" Zone = 270 Over 40" Zone = 330	Harding Lawson Associates
EF_{ressa}	Exposure frequency – resident soil adult (days/year)	Arctic Zone = 200 Under 40" Zone = 270 Over 40" Zone = 330	Harding Lawson Associates
EF_{ressc}	Exposure frequency – resident soil child (days/year)	Arctic Zone = 200 Under 40" Zone = 270 Over 40" Zone = 330	Harding Lawson Associates
EF_{resw}	Exposure frequency – resident groundwater (days/year)	350	U.S. EPA 1991a
EF_{reswa}	Exposure frequency – resident groundwater adult (days/year)	350	U.S. EPA 1991a
EF_{reswc}	Exposure frequency – resident groundwater child (days/year)	350	U.S. EPA 1991a
ET_{0-2}	Exposure time - age segment 0 – 2 years old (hours/day)	24	The whole day
ET_{2-6}	Exposure time - age segment 2 – 6 years old (hours/day)	24	The whole day
ET_{6-16}	Exposure time - age segment 6 – 16 years old (hours/day)	24	The whole day
ET_{16-26}	Exposure time - age segment 16 – 26 years old (hours/day)	24	The whole day
ET_{0-2}^{der}	Dermal exposure time - age segment 0 – 2 years old (hours/event)	0.54	U.S. EPA 2011
ET_{2-6}^{der}	Dermal exposure time - age segment 2 – 6 years old (hours/event)	0.54	U.S. EPA 2011
ET_{6-16}^{der}	Dermal exposure time - age segment 6 – 16 years old (hours/event)	0.71	U.S. EPA 2011
ET_{16-26}^{der}	Dermal exposure time - age segment 16 – 26 years old (hours/event)	0.71	U.S. EPA 2011
ET_{0-2}^{inh}	Inhalation exposure time - age segment 0 – 2 years old (hours/event)	24	The whole day
ET_{2-6}^{inh}	Inhalation exposure time - age segment 2 – 6 years old (hours/event)	24	The whole day
ET_{6-16}^{inh}	Inhalation exposure time - age segment 6 – 16 years old (hours/event)	24	The whole day
ET_{16-26}^{inh}	Inhalation exposure time - age segment 16 – 26 years old (hours/event)	24	The whole day
ET_{ress}	Exposure time - resident soil (hours/day)	24	The whole day
ET_{ressa}	Exposure time – resident soil adult (hours/day)	24	The whole day
ET_{ressc}	Exposure time – resident soil child (hours/day)	24	The whole day

Symbol	Definition (units)	Default	Reference(s)
ET_{resw}	Exposure time – resident groundwater (hours/day)	24	The whole day
ET_{resw}^{inh}	Inhalation exposure time – resident groundwater (hours/day)	24	The whole day
ET_{reswa}^{der}	Dermal exposure time – resident groundwater adult (hours/event)	0.71	U.S. EPA 2011
ET_{reswa}^{inh}	Inhalation exposure time – resident groundwater adult (hours/event)	24	The whole day
ET_{reswc}^{der}	Dermal exposure time – resident groundwater child (hours/event)	0.54	U.S. EPA 2011
ET_{reswc}^{inh}	Inhalation exposure time – resident groundwater child (hours/event)	24	The whole day
$ET_{resw\text{-}adj}^{der}$	Dermal exposure time – resident groundwater age-adjusted (hours/day)	0.67077	U.S. EPA 2011
$ET_{resw\text{-}adj}^{inh}$	Inhalation exposure time – resident groundwater age-adjusted (hours/day)	24	The whole day
$ET_{resw\text{-}madj}$	Mutagenic exposure time – resident groundwater age-adjusted (hours/day)	0.67077	U.S. EPA 2011
$EV_{0\text{-}2}$	Exposure events – age segment 0 – 2 years old (events/day)	1	U.S. EPA 2011
$EV_{2\text{-}6}$	Exposure events – age segment 2 – 6 years old (events/day)	1	U.S. EPA 2011
$EV_{6\text{-}16}$	Exposure events – age segment 6 – 16 years old (events/day)	1	U.S. EPA 2011
$EV_{16\text{-}26}$	Exposure events – age segment 16 – 26 years old (events/day)	1	U.S. EPA 2011
EV_{reswa}	Exposure events – resident groundwater adult (events/day)	1	U.S. EPA 2011
EV_{reswc}	Exposure events – resident groundwater child (events/day)	1	U.S. EPA 2011
F(x)	Function dependent on u_m / u_t (unitless)	Arctic Zone = 0.57 Under 40" Zone = 0.194 Over 40" Zone = 0.0616	U.S. EPA 1996a
f_{oc}	Fraction organic carbon in soil (g/g)	0.001 (0.1%)	U.S. EPA. 2002
I	Infiltration rate (m/year)	0.13	U.S. EPA. 2002

Symbol	Definition (units)	Default	Reference(s)
i	Hydraulic gradient (m/m)	0.002	U.S. EPA. 2002
$IFSM_{res\text{-}adj}$	Mutagenic soil ingestion rate – resident age-adjusted (mg/kg)	Arctic Zone = 95333 Under 40" Zone = 128700 Over 40" Zone = 157300	Calculated using the age adjusted intake factors equation
$IFS_{res\text{-}adj}$	Soil ingestion rate – resident age-adjusted (mg/kg)	Arctic Zone = 21000 Under 40" Zone = 28350 Over 40" Zone = 34650	Calculated using the age adjusted intake factors equation
$IFWM_{res\text{-}adj}$	Mutagenic groundwater ingestion rate – resident age-adjusted (L/kg)	1019.9	Calculated using the age adjusted intake factors equation
$IFW_{res\text{-}adj}$	Groundwater ingestion rate – resident age-adjusted (L/kg)	327.95	Calculated using the age adjusted intake factors equation
$IRS_{0\text{-}2}$	Soil ingestion rate - age-segment 0 – 2 years old (mg/day)	200	U.S. EPA 1991a (pg. 15)
$IRS_{2\text{-}6}$	Soil ingestion rate - age-segment 2 – 6 years old (mg/day)	200	U.S. EPA 1991a (
$IRS_{6\text{-}16}$	Soil ingestion rate - age-segment 6 – 16 years old (mg/day)	100	U.S. EPA 1991a
$IRS_{16\text{-}26}$	Soil ingestion rate - age-segment 16 – 26 years old (mg/day)	100	U.S. EPA 1991a
IRS_{iw}	Soil ingestion rate – indoor worker (mg/day)	50	U.S. EPA 1991a
IRS_{ow}	Soil ingestion rate – outdoor worker (mg/day)	100	U.S. EPA 1991a
IRS_{ressa}	Soil ingestion rate – resident soil adult (mg/day)	100	U.S. EPA 1991a
IRS_{ressc}	Soil ingestion rate – resident soil child (mg/day)	200	U.S. EPA 1991a
$IRW_{0\text{-}2}$	Resident groundwater ingestion rate - age-segment 0 – 2 years old (L/day)	0.78	U.S. EPA 2011
$IRW_{2\text{-}6}$	Resident groundwater ingestion rate - age-segment 2 – 6 years old (L/day)	0.78	U.S. EPA 2011
$IRW_{6\text{-}16}$	Resident groundwater ingestion rate - age-segment 6 – 16 years old (L/day)	2.5	U.S. EPA 2011
$IRW_{16\text{-}26}$	Resident groundwater ingestion rate - age-segment 16 – 26 years old (L/day)	2.5	U.S. EPA 2011
IRW_{iw}	Groundwater ingestion rate – indoor worker (L/day)	2.5	U.S. EPA 2011
IRW_{ow}	Groundwater ingestion rate – outdoor worker (L/day)	2.5	U.S. EPA 2011
IRW_{reswa}	Groundwater ingestion rate – resident groundwater adult (L/day)	2.5	U.S. EPA 2011
IRW_{reswc}	Groundwater ingestion rate – resident groundwater child (L/day)	0.78	U.S. EPA 2011

Symbol	Definition (units)	Default	Reference(s)
K	Andelman volatilization factor (L/m^3)	0.5	U.S. EPA 1991b
K	Aquifer hydraulic conductivity (m/year)	876	U.S. EPA. 2002
L	Source length parallel to ground water flow (m)	32	U.S. EPA. 2002
LT	Lifetime (years)	70	U.S. EPA 1989
n	Total soil porosity(L_{pore}/L_{soil})	= $1-(\varrho_b/\varrho_s)$ = 0.43396	U.S. EPA. 2002
PEF_w	Particulate emission factor (m^3/kg)	Arctic Zone = 1.47×10^9 Under 40" Zone = 1.36×10^9 Over 40" Zone = 1.28×10^9	Determined in the calculations
Q/C	Inverse of the mean concentration at the center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	Arctic Zone = 101.5958 Under 40" Zone = 93.7736 Over 40" Zone = 81.7066	Harding Lawson Associates
SA_{0-2}	Skin surface area – resident age segment 0 – 2 years old (cm^2)	Soil = 2373 Migration to Groundwater = 6365 Groundwater = 6365	U.S. EPA 2011
SA_{2-6}	Skin surface area – resident age segment 2 – 6 years old (cm^2)	Soil = 2373 Migration to Groundwater = 6365 Groundwater = 6365	U.S. EPA 2011
SA_{6-16}	Skin surface area – resident age segment 6 – 16 years (cm^2)	Soil = 6032 Migration to Groundwater = 19652 Groundwater = 20900	U.S. EPA 2011
SA_{16-26}	Skin surface area – resident age segment 16 – 26 years (cm^2)	Soil = 6032 Migration to Groundwater = 19652 Groundwater = 20900	U.S. EPA 2011
SA_{iw}	Skin surface area – indoor worker (cm^2)	3527	US EPA 2011
SA_{ow}	Skin surface area – outdoor worker (cm^2)	3527	US EPA 2011
SA_{ressa}	Skin surface area – resident soil adult (cm^2)	6032	U.S. EPA 2011
SA_{ressc}	Skin surface area – resident soil child (cm^2)	2373	U.S. EPA 2011
SA_{reswa}	Skin surface area – resident groundwater adult (cm^2)	19652	U.S. EPA 2011
SA_{reswc}	Skin surface area – resident groundwater child (cm^2)	6365	U.S. EPA 2011
T	Exposure interval (s)	819936000	U.S. EPA. 2002
THQ	Target hazard quotient	1.0	18 AAC 75.990(50)

Symbol	Definition (units)	Default	Reference(s)
TR	Target risk	1×10^{-5}	Determined in this calculator
U_m	Mean annual wind speed (m/s)	Arctic Zone = 5.77 Under 40" Zone = 4.69 Over 40" Zone = 4.07	U.S. EPA 1996a
U_t	Equivalent threshold value of wind speed at 7m (m/s)	11.32	U.S. EPA 1996a
V	Fraction of vegetative cover (unitless)	0.5	U.S. EPA 1996a
θ_a	Air-filled soil porosity (L_{air}/L_{soil})	$= n-\theta_w = 0.28396$	U.S. EPA. 2002
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15	U.S. EPA. 2002
ϱ_b	Dry soil bulk density (kg/L)	1.5	U.S. EPA. 2002
ϱ_s	Soil particle density (kg/L)	2.65	U.S. EPA. 2002

References for Cited Sources:

Harding Lawson Associates. 1995. Final Report Cleanup Level Matrix for Hazardous Substances in Soil Various Sites, Alaska.

U.S. EPA 1989. Risk assessment guidance for Superfund. Volume I: Human health evaluation manual (Part A). Interim Final. Office of Emergency and Remedial Response. EPA/540/1-89/002.

U.S.EPA 1991a. Human health evaluation manual, supplemental guidance: "Standard default exposure factors". OSWER Directive 9285.6-03.

U.S. EPA 1991b. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals). Office of Emergency and Remedial

U.S. EPA. 1996a. Soil Screening Guidance: User's Guide. Office of Emergency and Remedial Response. Washington, DC. OSWER No. 9355.4

U.S.EPA. 1996b. Soil Screening Guidance: Technical Background Document. Office of Emergency and Remedial Response. Washington, DC. OSWER No. 9355.4

U.S.EPA 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. December 2002.http://www.epa.gov/superfund/health/conmedia/soil/index.htm

U.S. EPA 2011. Exposure Factors Handbook: 2011 Edition. EPA/ 600/ R-090/052F, September 2011.

State of Alaska
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

DIVISION OF SPILL PREVENTION AND RESPONSE
CONTAMINATED SITES PROGRAM

Procedures for Calculating Cumulative Risk
September 15, 2016

Adopted by Reference at 18 AAC 75

PROCEDURES FOR CALCULATING CUMULATIVE RISK

TABLE OF CONTENTS

1.0 INTRODUCTION

The Alaska Department of Environmental Conservation (DEC) has developed rules at 18 AAC 75, Article 3 that detail the extent of cleanup required at contaminated sites in order to adequately protect human health, safety, and welfare and the environment. Included in these rules as well as the regulations for underground storage tanks at 18 AAC 78, is the requirement for ensuring that contaminants at a site do not exceed cumulative risk thresholds for carcinogenic and noncarcinogenic compounds, accounting for exposure to multiple contaminants across multiple pathways. This document describes the procedures for calculating that cumulative risk.

Under 18 AAC 75.325(g) or 18 AAC 78.600(d), a responsible party must ensure that contaminants remaining onsite do not exceed the cumulative risk standard of 1 in 100,000 excess lifetime cancer risk across all exposure pathways for carcinogens and a hazard index of not more than one, reported to one significant figure, across all exposure pathways for noncarcinogens, regardless of whether the cleanup levels established for the site are under method two, three, or four.

ADEC utilizes a sum-of-ratios approach for calculating cumulative risk. The approach is carried out in two separate calculations; one calculation for carcinogenic effects and one for noncarcinogenic effects. Separating risk quantification in this way is necessary due to differences between the two types of effects. For carcinogens, risk is evaluated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen (USEPA, 1989).

Within the carcinogenic category additional adjustments are incorporated if the chemical is considered to have a mutagenic mode of action. For noncarcinogens, risks are based on exposure over a threshold that is likely to be without effects. The calculations are then incorporated into a ratio approach and summed to quantify the cumulative risk. These procedures are for cumulative risk only and do not substitute for a baseline risk assessment.

Some compounds can cause both types of effects and are included in both cumulative risk calculations. For example, aldrin causes both carcinogenic and noncarcinogenic effects from soil exposure through the human health pathway. The cleanup level in Table B1 corresponds with the carcinogenic effect because it occurs at a lower concentration than does the noncarcinogenic effect.

1.1 Carcinogens

As stated in the preceding section, carcinogenic risk is estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a carcinogenic compound. Under 18 AAC 75.990(12), ADEC defines a carcinogen as "...a substance that meets the criteria of the descriptors "Carcinogenic to Humans" or "Likely to Be Carcinogenic to Humans" according to EPA's *Guidelines for Carcinogen Risk Assessment*, EPA/630/P-03/001F (USEPA, 2005).

Cumulative carcinogenic risk is the summation of all risks from each exposure pathway and exposure route. The cumulative carcinogenic risk equation is shown in Section 2.2. Unless demonstrated otherwise, cancer risks resulting from exposure to two or more carcinogens are assumed to be additive. The cumulative carcinogenic risk equation assumes that there are no synergistic or antagonistic chemical interactions.

1.2 Mutagens

Some of the carcinogenic compounds listed in Tables B1 and C operate by a mutagenic mode of action for carcinogenesis. Some chemicals with a mutagenic mode of action, which would be expected to cause irreversible changes to DNA, are suspected to exhibit a greater effect in early-life versus later-life exposure. Cancer risk to children in the context of EPA's cancer guidelines (USEPA, 2005) includes both early-life exposures that may result in the occurrence of cancer during childhood and early-life exposures that may contribute to cancers later in life. In keeping with this guidance, mutagenic cancer risk is calculated separately, and the mutagen vinyl chloride and trichloroethylene has a unique set of equations. However, when calculating cumulative risk, mutagens are included with carcinogens. Consult the Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F, March 2005 for further information.

1.3 Noncarcinogens

Under 18 AAC 75.990(69), ADEC defines a noncarcinogen as "…a hazardous substance with adverse health effects on humans other than cancer." The noncarcinogenic risk is represented by a hazard quotient (HQ), which is calculated from the ratio of estimated intake of a chemical to the estimated intake at which there are no observed adverse effects. The hazard index (HI) is the summation of all of the HQs for all pathways and exposure routes that affect the same target organ or system endpoint.

For noncarcinogens, the health threats resulting from exposure to two or more hazardous substances with similar types of toxic response are assumed to be additive. However, many noncarcinogens have varying toxic effects and therefore assuming that these effects are additive may not be valid. Noncarcinogenic compounds affect different target organs or systems by different mechanisms of toxicity. To accurately assess the possible effects of noncarcinogenic compounds, the HI can be segregated by target organ or system endpoint and mechanism of toxicity consistent with EPA's *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A) – Interim Final* (USEPA, 1989), *Guidelines for the Health Risk Assessment of Chemical Mixtures* (USEPA, 1986), and *Supplemental Guidance for Conducting Health Risk Assessment of Chemical Mixtures* (USEPA, 2000). Since the mechanism of toxicity is not well understood for many compounds, the department will evaluate segregation of the HI by target organ or system endpoint.

2.0 CALCULATING CUMULATIVE RISK

Cumulative risk is defined as the sum of risks resulting from multiple sources and pathways via which humans are exposed. When more than one hazardous substance is present at a site or multiple exposure pathways exist, the cleanup levels in Table B1 of 18 AAC 75.341 and Table C of 18 AAC 75.345 (hereinafter "Table B1"and "Table C") may need to be adjusted downward. The cumulative cancer risk remaining at the site when cleanup is completed must not exceed 1 in 100,000 (1×10^{-5}) unless otherwise approved by ADEC, and must not exceed the cumulative noncarcinogenic risk standard at a hazard index (HI) of one, reported to one significant figure.

1. When to Perform the Cumulative Risk Analysis

The cumulative risk standard must be met upon completion of site cleanup work, but the department advises that responsible parties be cognizant early on of potential cumulative risk issues to allow adjustments to the scope of the cleanup and avoid remobilization to the site post-cleanup. Therefore, it may be prudent to calculate cumulative risk as soon as adequate and representative data is available. The department does not require that gasoline, diesel and residual range petroleum

hydrocarbon fractions (see both Table B2 of 18 AAC 75.341 and Table C) be included in cumulative risk calculations, since selected individual compounds from the fractions are accounted for in Table B1 and Table C. However the risk may be underestimated since each fraction can consist of several other compounds not accounted for. See section 5.6 for more information.

2. Procedures

The process for calculating cumulative risk is as follows:

1. Determine which compounds are considered chemicals of potential concern (COPCs) for inclusion in the calculation of cumulative risk. These chemicals will correspond to a HQ of 0.1 or cancer risk of 1×10^{-6} for the residential exposure scenario. COPCs can be determined using the maximum soil concentration of each contaminant at the site that exceeds $1/10^{th}$ of the human health levels in Table B1 for the applicable climate zone.[1] For groundwater, the maximum concentration is compared against $1/10^{th}$ of the cleanup levels in Table C (see Section 3.0 for addressing cumulative risk in groundwater). If no chemicals at the site exceed the 1/10th threshold for either media, or only petroleum range contamination is present, cumulative risk does not need to be calculated for the site. For help on how to evaluate compounds not listed in ADEC tables, see Section 5.4.

   Please note that some chemicals listed in Tables B1 and C are capped at saturation or solubility levels that are lower than the actual risk-based value. Using the 1/10th threshold may not adversely influence the calculation; however, adjustments may be needed for saturation or solubility-capped chemicals if several are COPCs at the site. The adjustments can be made to correspond to a HQ of 0.1 or cancer risk of 1×10^{-6} with ADEC cumulative risk tools. Please consult with ADEC staff for assistance in calculating the values.

2. When COPCs are present, develop a conceptual site model (CSM) that shows all of the complete exposure pathways at the site. A CSM should include the source of contamination, release/transport mechanisms, contact media (i.e. soil, air, or groundwater), exposure route (i.e., dermal contact, inhalation, ingestion) and receptor (i.e. current/future resident, subsistence user, or biota). For more information on developing a CSM, refer to the department's Guidance on Developing Conceptual Site Models (ADEC, 2010).

3. Using the worksheet example in Appendix A, record the following information for each contaminant:

   a) whether the contaminant is considered a carcinogen, noncarcinogen, or both (if it is a mutagen, record it as a carcinogen);
   b) the exposure media (soil, groundwater, air)
   c) exposure route (ingestion, inhalation of volatiles and/or particulates, dermal contact)
   d) maximum concentration or the mean soil concentration at the 95^{th} percent upper confidence limit (UCL) remaining on-site following cleanup[2]; and

---

[1] 1/10 of the cleanup level corresponds to a HQ of 0.1 and cancer risk of 10E-6.

[2] To employ the mean soil concentration at the 95% UCL under 18 AAC 75.380(c)(1), the department must approve an appropriate statistical method. As stated above, for groundwater, the site concentration is the maximum concentration, as described in 18 AAC 75.380(c)(2).

e) the corresponding risk-based concentration (RBC) in Appendix B for soil or groundwater.

RBCs correspond to the concentration in soil that would cause an adverse effect through the inhalation, ingestion, or dermal contact routes of exposure. RBCs are calculated using the equations presented in ADEC's PCCL 2016 and take into account default exposure and soil/aquifer data as well as toxicological data specific to the compound of interest. The RBCs differ from Table B1 and Table C in that individual exposure pathways are shown rather than individual exposure pathways are shown rather than the cumulative risk from the respective media listed in the Tables. Also, some cleanup levels in Table B1 are capped at the soil saturation concentration and therefore may equate to a lifetime cancer risk or HI that is lower than the department standard.

4. For each carcinogen, risk is calculated by dividing the maximum site concentration or the mean of the 95 UCL remaining on-site by the applicable RBC and multiplying by the risk management level of 1×10^{-5}. Cumulative carcinogenic risk is the summation of all the risks from each exposure pathway and exposure route. The equation is as follows:

$$Cumulative\ Carcinogenic\ Risk = \left[\left(\frac{conc_x}{RBC_x}\right) + \left(\frac{conc_y}{RBC_y}\right) + \left(\frac{conc_z}{RBC_z}\right) \ldots\right] \times 10^{-5}$$

5. For each noncarcinogen, the hazard quotient (HQ) is calculated by dividing the site concentration remaining on-site by the applicable RBC and multiplying by the risk management level of 1. The hazard index (HI) is the summation of all HQs across all pathways that are affecting the same target organ or system endpoint. The equation is as follows:

$$Hazard\ Index = \left[\left(\frac{conc_x}{RBC_x}\right) + \left(\frac{conc_y}{RBC_y}\right) + \left(\frac{conc_z}{RBC_z}\right) \ldots\right] \times 1$$

Soil cleanup levels through methods two and three address ingestion of soil, inhalation of volatile chemicals and chemical particulates from soil in outdoor ambient air, and dermal contact with soil. Cleanup levels for groundwater at Table C address ingestion of groundwater, dermal contact with groundwater, and inhalation of volatiles from groundwater.

All other pathways that are shown to be complete based on the site-specific CSM should be investigated. These include indoor air from vapor intrusion as well as consumption of wild foods or exposure as a result of other site uses. The vapor intrusion pathway can be addressed through a site-specific analysis following ADEC's Vapor Intrusion Guidance 2012, while other pathways can be addressed through a method four risk assessment.

The RBCs for compounds not listed in Tables B1 and C and for compounds where alternative cleanup levels under method three are proposed, must be calculated on a site-specific basis using ADEC's Risk Assessment Procedures Manual (RAPM 2015).

3.0 CUMULATIVE RISK AND GROUNDWATER

Unless it is shown that the groundwater at the site is not used or could not potentially be used for human consumption, it should be assumed that these groundwater pathways are complete. Therefore, chemicals found in groundwater at one-tenth of the Table C values need to be included in the cumulative risk calculations.

Table C values were developed using ADEC's PCCL 2016. Levels developed using the risk-based equations in that document are based on an HQ of 1 or a lifetime excess cancer risk of 1×10^{-5} for ingestion of groundwater, inhalation of volatiles from groundwater and dermal contact with groundwater. The RBCs associated with the three groundwater exposure pathways can be found in Appendix B.

4.0 CUMULATIVE RISK UNDER METHOD FOUR

When conducting a method four risk assessment, compounds found at levels that correspond to greater than the risk based benchmarks of 1×10^{-6} risk or HQ of 0.1 will be retained for further analysis and are therefore included in the cumulative risk calculations. See ADEC's RAPM 2015 for more information.

5.0 CHEMICALS WITH SPECIAL CONSIDERATIONS

The following sections detail procedures for incorporating PCBs, dioxins, and lead in cumulative risk calculations. For additional information and assistance with these compounds please contact ADEC's risk assessor.

5.1 PCBs

Polychlorinated biphenyls (PCBs) are included in cumulative risk calculations although the cleanup levels are determined on a site-specific basis, based on land use, or through a site-specific risk assessment. If separate congener or Aroclor concentrations are present, the appropriate toxicological data can be used to calculate cancer risk. At the time of this document, EPA's *Integrated Risk Information System* (IRIS) had individual assessments for seven different Aroclors: 1016, 1221, 1232, 1242, 1248, 1254 and 1260.[3] In addition IRIS has individual assessments for a handful of specific congeners. If PCBs are presented as a total concentration, the most conservative cancer slope factor and reference dose should be used.

5.2 Dioxins

Risks from dioxins are calculated based on a 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) toxicity equivalent (TEQ) approach and should be included in cumulative risk calculations. Toxicity equivalency factors (TEFs) are used to compare the relative toxicity of individual dioxin-like compounds to the more toxic TCDD. Included in this calculation are dioxins, furans, and dioxin-like PCBs. The TEQ approach is based on the assumption that dioxin and dioxin-like compounds act through the same mechanism of toxicity. The TEF for TCDD is equal to one, whereas the TEF values for all other dioxins and dioxin-like compounds are equal to less than one. The TEQ is

[3] Available at: http://www.epa.gov/IRIS/

defined as the product of the concentration of an individual dioxin-like compound (Ci) and the corresponding TEF for that compound (TEFi). The total TEQ is the sum of the TEQ for each of the congeners in a given mixture.

$$Total\ TEQ = \sum(Ci \times TEFi)$$

Once the total TEQ is calculated, this value can be compared to the dioxin slope factor and the risk can be calculated. The most current toxicological data and TEFs should be used when calculating risk to dioxins. The World Health Organization remains the leading recommended approach for TEFs.[4]

5.3 Lead

Lead contamination in soil or groundwater is not included in cumulative risk calculations. EPA found it inappropriate to apply a reference dose or cancer slope factor to lead (IRIS, 1988). The residential lead soil cleanup level in Table B1 is based on the Integrated Exposure Uptake Biokinetic (IEUBK) model. Soil cleanup levels for lead are site-specific, based on land use, and groundwater cleanup levels are presented in Table C. In addition, an alternative cleanup level may be proposed under a site-specific risk assessment.

Lead cleanup levels are based on land use; for residential land use, the soil cleanup level is 400 mg/kg. For commercial or industrial land use as applied in 18 AAC 75.340(e)(3), the soil cleanup level is 800 mg/kg. As part of a site-specific risk assessment conducted according to the RAPM 2015, approved exposure models may be used to evaluate exposure to a child resident or an adult worker. A responsible person may also propose an alternative cleanup level based on a chemical speciation of the lead present at the site, under a site-specific risk assessment. For soils contaminated with lead more than 15 feet below ground surface, lead cleanup levels will be determined on a site-specific basis.

5.4 Chemicals Not Found in ADEC Tables

To evaluate cumulative risk from a chemical for which no ADEC regulatory criteria is available, the first step is to consult the EPA Regional Screening Levels (RSL) table (available at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm) and compare the site concentration with the listed screening level for residential receptors. If it exceeds the value listed, which equates to a noncarcinogenic risk at HQ= 0.1 and cancer risk at 1×10^{-6} then consult with ADEC staff to calculate a method two cleanup level using the process outlined in the RAPM 2015. Toxicity and chemical data specific to the compound of concern will be needed. Toxicity data can be obtained from EPA's IRIS, EPA's *Provisional Peer Reviewed Toxicity Values (PPRTVs)*[5], or another accepted source (see Appendix C). Chemical data can be obtained from an accepted chemistry source such as the Risk Assessment Information System (RAIS).[6] When compounds are not listed in ADEC and RSL tables please consult with ADEC staff.

---

[4] World Health Organization. 2005. International Programme on Chemical Safety, Toxicity equivalent factors for dioxins, furans, and dioxin-like PCBs. Available at: http://www.who.int/ipcs/assessment/tef_values.pdf

[5] Available at: http://hhpprtv.ornl.gov/

[6] Available at: http://rais.ornl.gov/

Next, if the highest concentration remaining in soil or groundwater exceeds $1/10^{th}$ of the calculated value, proceed with the steps as described in Section 2.2 of these procedures, including evaluating complete exposure pathways and comparing with the route-specific RBC(s) developed as part of the cleanup criteria calculations and validated by ADEC.

5.5 Naturally Occurring Compounds

DEC recommends the use of the U.S. Environmental Protection Agency's *Guidance for Comparing Background and Chemical Concentrations in Soil for Comprehensive Environmental Response Compensation and Liability Act (CERCLA) Sites* (USEPA, 2002), for determining if compounds found on site are attributable to background levels. If a chemical found at the site is shown to be solely attributable to naturally occurring background concentrations, then the chemical is not included in the cumulative risk calculations.

5.6 Petroleum Hydrocarbons

Each petroleum fraction is a mixture of many different chemicals. The Total Petroleum Hydrocarbon Criteria Working Group identified indicator contaminants to represent the toxicity of the petroleum fractions. Individual risks for each petroleum fraction are then calculated based on these indicator compounds (listed in the table below). In order to accomplish this, analytical data for these compounds must be collected at sites with petroleum contamination. If these indicator compounds are not present at greater than 1/10 of the cleanup level in Tables B1 and C, then no further assessment of cumulative risk is required; however site cleanup levels for petroleum fractions still must be met.

INDICATOR COMPOUNDS FOR PETROLEUM CONTAMINATED SITES	
Volatiles (BTEX) Benzene* Toluene Ethylbenzene* Total xylenes *Polynuclear Aromatic Hydrocarbons (PAHs)* - Acenaphthene Acenaphthylene Anthracene Benzo(a)anthracene* Benzo(b)fluroranthene* Benzo(k)fluoranthene* Benzo(g,h,i)perylene Benzo(a)pyrene* Chrysene * Dibenzo(a,h)anthracene* Fluoranthene Fluorene Indeno(1,2,3-cd)pyrene* Naphthalene* Phenanthrene Pyrene	*Metals as required on a case by case basis* Arsenic* Barium Cadmium Chromium*† Lead Nickel Vanadium *Others as needed on a case by case basis* Ethylene dibromide (EDB)* 1,2-dichloroethane (EDC)* Methyl tert-butyl ether (MTBE)* Volatile organic compounds (VOCs)*

* indicates carcinogenic

† Chromium includes both III and VI valances, but only VI is carcinogenic.

The carcinogenic risk of petroleum can be adequately evaluated by determining the risk from carcinogenic indicator compounds. Using the same rationale, noncarcinogenic effects of petroleum can be evaluated by calculating the HI for the indicator contaminants listed in Tables B1 and C. Therefore, the department believes that calculating cumulative risk for the indicator contaminants, in addition to other contaminants on-site, is protective of the cumulative risk to petroleum exposure, provided that site cleanup levels for the petroleum fractions are also met.

The department understands that there are petroleum constituents that will not be captured using this method. For many of these constituents the toxicity of the compounds has not yet been determined or there is minimal risk due to exposure. Petroleum is a chemical mixture. Under the *Guidelines for the Health Risk Assessment of Chemical Mixtures* (USEPA, 1986), the most preferred method for evaluating the risk to chemical mixtures is to use toxicological data for the mixture itself. Many mixtures have different toxicological properties than their constituents. The best available method for assessing risk to petroleum mixtures is to use a surrogate approach to determine cumulative risk. This is done by developing reference doses for each carbon range and then summing the HQs to produce the HI as explained in the PCCL 2016. However, at this time, there is not enough toxicological data available to calculate risk from the full petroleum fractions. Mixtures in petroleum fractions vary by product type and refining process and are altered further by weathering in the environment.

In light of this level of uncertainty, the PCCL 2016 attempts to compensate for the unknown risk from the six aromatic and aliphatic fractions by adopting conservative percentages for the composition of each fraction within each petroleum range (gasoline range organics, diesel range organics, and residual range organics); therefore the fractions are not included in the cumulative risk calculations where the petroleum indicator compounds are used. See Section 6.10 of the PCCL 2016 for more information. The department continues to investigate this issue with the goal of decreasing the uncertainty for risk with a scientifically accurate approach to quantifying the full risk from the petroleum fractions.

6.0 CUMULATIVE RISK CALCULATIONS FOR METHOD THREE

If alternative cleanup levels have been developed under method three, the carcinogenic risk or HQ from each constituent and the cumulative risk are calculated in the same fashion as described in Section 2.2. The site concentration following cleanup is divided by the RBC and the quotient is multiplied by the target risk standard. When using method three cleanup levels with site-specific data, the RBCs in Appendix B cannot be used; instead the same site-specific parameters must be used to produce the method three RBCs. See ADEC's PCCL 2016.

7.0 ADDITIONAL PATHWAYS TO INVESTIGATE

Upon completion of the CSM evaluation, exposure pathways other than those accounted for in Tables B1, B2 and C may be found to be complete. Such exposure pathways may include the indoor air vapor pathway, consumption of cultivated or wild foods at the site, and exposures based on recreational use. Vapor intrusion may be addressed through a site-specific analysis using ADEC's Vapor Intrusion Guidance (2012), while other pathways will require a method four risk assessment. Tables B1, B2 and C include the following exposure routes for soil: dermal contact, ingestion, and inhalation of volatiles and particulates from ambient air; and include the following exposure routes for groundwater: dermal contact, ingestion, and inhalation of volatiles. All completed pathways must be included in cumulative risk calculations including those pathways not addressed in Tables B1 and C.

8.0 ROUNDING IN CUMULATIVE RISK

Under 18 AAC 75.325(g) or 18 AAC 78.600(d), a responsible person must ensure that, after completing site cleanup using methods two or three, the risk from hazardous substances does not exceed a cumulative carcinogenic risk standard of 1 in 100,000 across all exposure pathways and a

cumulative noncarcinogenic risk standard at a hazard index of 1, rounded to one significant figure, for all exposure pathways. Similarly, under 18 AAC 75.325(h), a responsible person proposing an alternative cleanup level for soil or groundwater based on a site-specific risk assessment under method four must ensure that the risk from hazardous substances does not exceed the cumulative carcinogenic risk standard of 1 in 100,000 across all exposure pathways and the cumulative noncarcinogenic risk standard at a hazard index of 1 for all exposure pathways.

Both cumulative risk summations for the incremental lifetime cancer risk and the HI should be expressed using one significant figure. The risk for an individual exposure pathway for a chemical, either the cancer risk or the hazard quotient should be shown to two significant figures. These then would be rounded to one significant figure after calculating the cumulative risk.
Standard rounding procedures must be adhered to such that:

Starting from the left most significant digit, move to the right until you have as many digits as you are allowed to keep. Then look to the immediate right and note the number present. If the number to the right is a 5, 6, 7, 8, or 9, round the last significant digit up one. If the number to the right is a 4, 3, 2, 1, or 0, keep the last significant digit the same. Therefore, the rounding procedures and cumulative risk standards are consistent between methods two, three, and four.

9.0 ECOLOGICAL RECEPTORS

The noncarcinogenic HI is calculated for ecological receptors. The ecological noncarcinogenic risk management level is set at a HI of 1. Carcinogens are not considered to be of concern for ecological receptors. The HI is the sum of HQs across multiple exposure routes and exposure pathways. The HQ is calculated by dividing the dose by a risk-based ecological benchmark.

$$HI = \Sigma Dose \div Benchmark$$

If the HI exceeds 1, the individual HQs should be retained for further evaluation. See ADEC's RAPM 2015 for additional information.

REFERENCES

Alaska Department of Environmental Conservation (ADEC). 2002. *Oil and Hazardous Substances Pollution Control Regulations 18AAC 75, Articles 3 and 9.*

ADEC. 2016. *Procedures for Calculating Cleanup Levels.* Contaminated Sites Program.

ADEC. 2015. *Risk Assessment Procedures Manual.* Contaminated Sites Remediation Program.

Total Petroleum Hydrocarbon Criteria Working Group. 1997. *Volume 4, Development of Fraction Specific Reference Doses (RfDs) and Reference Concentrations (RfCs) for Total Petroleum Hydrocarbons (TPH).* Amherst Scientific Publishers, Amherst, MA.

United States Environmental Protection Agency (USEPA). March 2005 Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. EPA/630/R-03/003F. Risk Assessment Forum, Washington, DC.

United States Environmental Protection Agency (USEPA). 1997. *Health Effects Assessment Summary Tables: FY 1997 Update.* EPA/540/R-97-036. Office of Emergency and Remedial Response, Washington, DC.

USEPA. 1996. *Soil Screening Guidance: Technical Background Document.* EPA/540/R-95/128. Office of Solid Waste and Emergency Response, Washington, DC.

USEPA. 1996. *Soil Screening Guidance: User's Guide.* 9355.4-23. Office of Solid Waste and Emergency Response, Washington DC.

USEPA. 1989. *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A).* EPA/540/1-89/002. Office of Emergency and Remedial Response, Washington, DC.

USEPA. 1988. *Integrated Risk Information System: Lead and Compounds (Inorganic). http://www.epa.gov/iris/subst/0277.htm.* Office of Research and Development, Washington, DC.

USEPA. 1986. *Guidelines for the Health Risk Assessment of Chemical Mixtures.* EPA/630/R-98/002. Office of Research and Development, Washington, DC.

APPENDIX A: WORKSHEET FOR CALCULATING CUMULATIVE RISK

Chemicals of Concern Carcinogens	Exposure Media	Exposure Route	Site Concentration (mg/kg, mg/L or mg/m^3)	RBC	Conc÷RBC
Cumulative Carcinogenic Risk = $\left[\left(\frac{conc_x}{RBC_x}\right)+\left(\frac{conc_y}{RBC_y}\right)+\left(\frac{conc_z}{RBC_z}\right)\ldots\right]\times 10^{-5}$				Σ (Conc÷RBC) $\times 10^{-5}$	Total
Chemicals of Concern Noncarcinogens	**Exposure Media**	**Exposure Route**	**Site Concentration (mg/kg, mg/L or mg/m^3)**	**RBC**	**Conc÷RBC**
Cumulative Noncarcinogenic Risk = $\left[\left(\frac{conc_x}{RBC_x}\right)+\left(\frac{conc_y}{RBC_y}\right)+\left(\frac{conc_z}{RBC_z}\right)\ldots\right]\times 1$				Σ (Conc÷RBC) X 1	Total

mg/kg = milligrams per kilogram
mg/L – milligrams per liter
RBC = risk based concentration

_____
Site Name

APPENDIX B: HUMAN HEALTH RISK BASED CONCENTRATIONS

SOIL ARCTIC ZONE

SOIL ARCTIC ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic?	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Acenaphthene	83-32-9	No	8210	26600	-	-	-	-
Acenaphthylene	208-96-8	No	4110	13300	-	-	-	-
Acetone	67-64-1	No	123000	-	1.09×10^6	-	-	-
Aldrin	309-00-2	No	4.11	-	-	0.716	-	10.4
Ammonium Perchlorate	7790-98-9	No	95.8	-	-	-	-	-
Anthracene	120-12-7	No	41100	133000	-	-	-	-
Antimony (metallic)	7440-36-0	No	54.8	-	-	-	-	-
Arsenic, Inorganic	7440-38-2	No	68.4	577	7360	13.5	96.1	3070
Barium	7440-39-3	No	27400	-	245000	-	-	-
Benz[a]anthracene	56-55-3	Yes	-	-	-	3.67	11.0	429
Benzaldehyde	100-52-7	No	13700	-	-	3040	-	-
Benzene	71-43-2	No	548	-	154	221	-	17.7
Benzo[a]pyrene	50-32-8	Yes	-	-	-	0.367	1.10	4340
Benzo[b]fluoranthene	205-99-2	Yes	-	-	-	3.67	11.0	43400
Benzo[g,h,i]perylene	191-24-2	No	4110	13300	-	-	-	-
Benzo[k]fluoranthene	207-08-9	Yes	-	-	-	36.7	110	43400
Benzoic Acid	65-85-0	No	548000	2.31×10^6	-	-	-	-
Benzyl Alcohol	100-51-6	No	13700	57700	-	-	-	-
Beryllium and compounds	7440-41-7	No	274	-	9820	-	-	5510
Bis(2-chloroethyl)ether	111-44-4	No	-	-	-	11.1	-	6.34
Bis(2-ethylhexyl)phthalate	117-81-7	No	2740	11500	-	869	3090	5.51×10^6
Bromobenzene	108-86-1	No	1100	-	658	-	-	-
Bromodichloromethane	75-27-4	No	2740	-	-	196	-	5.45
Bromoform	75-25-2	No	2740	-	-	1540	-	438
Bromomethane	74-83-9	No	192	-	16.1	-	-	-
Butadiene, 1,3-	106-99-0	No	-	-	4.16	3.58	-	1.87
Butanol, N-	71-36-3	No	13700	-	-	-	-	-
Butyl Benzyl Phthlate	85-68-7	No	27400	115000	-	6400	22800	-
Butylbenzene, n-	104-51-8	No	6840	-	-	-	-	-
Butylbenzene, sec-	135-98-8	No	13700	-	-	-	-	-
Butylbenzene, tert-	98-06-6	No	13700	-	-	-	-	-
Cadmium (Diet)	7440-43-9	No	137	1440	4910	-	-	7340
Carbon Disulfide	75-15-0	No	13700	-	1830	-	-	-

SOIL ARCTIC ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Carbon Tetrachloride	56-23-5	No	548	-	320	174	-	14.4
Chlordane	12789-03-6	No	68.4	721	1180	34.8	309	455
Chlordecone (Kepone)	143-50-0	No	41.1	173	-	1.22	4.32	2870
Chloroaniline, p-	106-47-8	No	548	2310	-	60.8	216	-
Chlorobenzene	108-90-7	No	2740	-	424	-	-	-
Chloroform	67-66-3	No	1370	-	494	392	-	5.93
Chloromethane	74-87-3	No	-	-	246	-	-	-
Chloronaphthalene, Beta-	91-58-7	No	11000	35500	-	-	-	-
Chlorophenol, 2-	95-57-8	No	684	-	-	-	-	-
Chromium(III), Insoluble Salts	16065-83-1	No	205000	-	-	-	-	-
Chromium(VI)	18540-29-9	Yes	411	-	49100	5.36	-	56.8
Chrysene	218-01-9	Yes	-	-	-	367	1100	434000
Copper	7440-50-8	No	5480	-	-	-	-	-
Cresol, m-	108-39-4	No	6840	28800	2.95×10^8	-	-	-
Cresol, o-	95-48-7	No	6840	28800	2.95×10^8	-	-	-
Cresol, p-	106-44-5	No	13700	57700	2.95×10^8	-	-	-
Cumene	98-82-8	No	13700	-	3040	-	-	-
Cyanide (CN-)[5]	57-12-5	No	82.1	-	116	-	-	-
Cyclohexane	110-82-7	No	-	-	13800	-	-	-
DDD	72-54-8	No	-	-	-	50.7	180	192000
DDE, p,p'-	72-55-9	No	-	-	-	35.8	-	645
DDT	50-29-3	No	68.4	961	-	35.8	424	136000
Dibenz[a,h]anthracene	53-70-3	Yes	-	-	-	0.367	1.10	3980
Dibenzofuran	132-64-9	No	137	1920	-	-	-	-
Dibromochloromethane	124-48-1	No	2740	-	-	145	-	-
Dibromoethane, 1,2-	106-93-4	No	1230	-	137	6.08	-	0.685
Dibromomethane (Methylene Bromide)	74-95-3	No	-	-	45.2	-	-	-
Dibutyl Phthalate	84-74-2	No	13700	57700	-	-	-	-
Dichlorobenzene, 1,2-	95-50-1	No	12300	-	2890	-	-	-
Dichlorobenzene, 1,3-	541-73-1	No	12300	-	2470	-	-	-
Dichlorobenzene, 1,4-	106-46-7	No	9580	-	10400	2250	-	31.7
Dichlorobenzidine, 3,3'-	91-94-1	No	-	-	-	27.0	96.1	38900
Dichlorodifluoromethane	75-71-8	No	27400	-	220	-	-	-
Dichloroethane, 1,1-	75-34-3	No	27400	-	-	2130	-	69.0
Dichloroethane, 1,2-	107-06-2	No	821	-	57.0	134	-	8.44

SOIL ARCTIC ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic?	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Dichloroethylene, 1,1-	75-35-4	No	6840	-	517	-	-	-
Dichloroethylene, 1,2-cis-	156-59-2	No	274	-	-	-	-	-
Dichloroethylene, 1,2-trans-	156-60-5	No	2740	-	-	-	-	-
Dichlorophenol, 2,4-	120-83-2	No	411	1730	-	-	-	-
Dichlorophenoxy Acetic Acid, 2,4-	94-75-7	No	1370	11500	-	-	-	-
Dichloropropane, 1,2-	78-87-5	No	12300	-	25.2	338	-	17.0
Dichloropropene, 1,3-	542-75-6	No	4110	-	115	122	-	38.8
Dieldrin	60-57-1	No	6.84	28.8	-	0.760	2.70	2870
Diethyl Phthalate	84-66-2	No	110000	461000	-	-	-	-
Dimethylphenol, 2,4-	105-67-9	No	2740	11500	-	-	-	-
Dimethylphthalate	131-11-3	No	110000	461000	-	-	-	-
Dinitrobenzene, 1,2-	528-29-0	No	13.7	57.7	-	-	-	-
Dinitrobenzene, 1,3-	99-65-0	No	13.7	57.7	-	-	-	-
Dinitrobenzene, 1,4-	100-25-4	No	13.7	57.7	-	-	-	-
Dinitrophenol, 2,4-	51-28-5	No	274	1150	-	-	-	-
Dinitrotoluene, 2,4-	121-14-2	No	274	1130	-	39.2	137	149000
Dinitrotoluene, 2,6-	606-20-2	No	41.1	175	-	8.11	29.1	-
Dinitrotoluene, 2-Amino-4,6-	35572-78-2	No	274	19200	-	-	-	-
Dinitrotoluene, 4-Amino-2,6-	19406-51-0	No	274	12800	-	-	-	-
Dioxane, 1,4-	123-91-1	No	4110	-	3040	122	-	546
Diphenylamine	122-39-4	No	3420	14400	-	-	-	-
Endosulfan	115-29-7	No	821	-	-	-	-	-
Endrin	72-20-8	No	41.1	173	-	-	-	-
Ethyl Chloride	75-00-3	No	-	-	28500	-	-	-
Ethylbenzene	100-41-4	No	13700	-	7130	1110	-	76.8
Ethylene Glycol	107-21-1	No	274000	1.15×10^6	1.96×10^8	-	-	-
Fluoranthene	206-44-0	No	5480	17700	-	-	-	-
Fluorene	86-73-7	No	5480	17700	-	-	-	-
Formaldehyde	50-00-0	No	27400	-	2030	-	-	427
Heptachlor	76-44-8	No	68.4	-	-	2.70	-	11.0
Heptachlor Epoxide	1024-57-3	No	1.78	-	-	1.34	-	9.71
Hexachlorobenzene	118-74-1	No	110	-	-	7.60	-	4.45
Hexachlorobutadiene	87-68-3	No	137	-	-	156	-	15.9
Hexachlorocyclohexane, Alpha-	319-84-6	No	1100	4610	-	1.93	6.86	7340
Hexachlorocyclohexane, Beta-	319-85-7	No	-	-	-	6.76	24.0	24900

SOIL ARCTIC ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Hexachlorocyclohexane, Gamma- (Lindane)	58-89-9	No	41.1	433	-	11.1	98.3	42600
Hexachlorocyclopentadiene	77-47-4	No	821	-	2.05	-	-	-
Hexachloroethane	67-72-1	No	95.8	-	326	304	-	26.6
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	No	411	11500	-	111	2620	-
Hexane, N-	110-54-3	No	-	-	1540	-	-	-
Hexanone, 2-	591-78-6	No	684	-	845	-	-	-
Hydrazine	302-01-2	No	-	-	5.34	4.06	-	0.978
Indeno[1,2,3-cd]pyrene	193-39-5	Yes	-	-	-	3.67	11.0	43400
Isophorone	78-59-1	No	27400	115000	9.82x 10[8]08	12800	45500	-
Isopropanol	67-63-0	No	274000	-	14500	-	-	-
Mercuric Chloride	7487-94-7	No	41.1	-	147000	-	-	-
Mercury (elemental)	7439-97-6	No	21.9	-	28.3	-	-	-
Methanol	67-56-1	No	274000	-	1.54 x 10^6	-	-	-
Methoxychlor	72-43-5	No	684	2880	-	-	-	-
Methyl Ethyl Ketone (2-Butanone)	78-93-3	No	82100	-	150000	-	-	-
Methyl Isobutyl Ketone (4-methyl-2-pentanone)	108-10-1	No	-	-	69200	-	-	-
Methyl Mercury	22967-92-6	No	13.7	-	-	-	-	-
Methyl tert-Butyl Ether (MTBE)	1634-04-4	No	-	-	32700	6760	-	1130
Methylene Chloride	75-09-2	Yes	821	-	2710	1340	-	4390
Methylnaphthalene, 1-	90-12-0	No	9580	31100	-	420	1150	-
Methylnaphthalene, 2-	91-57-6	No	548	1770	-	-	-	-
Naphthalene	91-20-3	No	2740	8870	158	-	-	41.8
Nickel Soluble Salts	7440-02-0	No	2740	-	44200	-	-	50800
Nitrobenzene	98-95-3	No	274	-	848	-	-	63.4
Nitroglycerin	55-63-0	No	13.7	57.7	-	716	2540	-
Nitroguanidine	556-88-7	No	13700	57700	-	-	-	-
Nitrosodimethylamine, N-	62-75-9	Yes	1.10	-	6.45	0.0526	-	0.112
Nitroso-di-N-propylamine, N-	621-64-7	No	-	-	-	1.74	6.18	6610
Nitrosodiphenylamine, N-	86-30-6	No	-	-	-	2480	8830	5.08 x 10^6
Nitrotoluene, m-	99-08-1	No	13.7	57.7	-	-	-	-
Nitrotoluene, o-	88-72-2	No	123	-	-	55.3	-	-
Nitrotoluene, p-	99-99-0	No	548	2310	-	760	2700	-

Sulfonate ACT

SOIL ARCTIC ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[3]	Dermal[3]	Inhalation[4]	Ingestion[3]	Dermal[3]	Inhalation[4]
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	No	6840	481000	-	-	-	-
Octyl Phthalate, di-N-	117-84-0	No	1370	5770	-	-	-	-
Pentachlorophenol	87-86-5	No	684	1150	-	30.4	43.2	2.59×10^6
Pentaerythritol tetranitrate (PETN)	78-11-5	No	274	1150	-	3040	10800	-
Perfluorooctane ~~Sulphonic Acid~~ (PFOS)	1763-23-1	No	2.74	11.5	-	-	-	-
Perfluorooctanoic Acid (PFOA)	335-67-1	No	2.74	11.5	-	174	618	-
Phenanthrene	85-01-8	No	4110	13300	-	-	-	-
Phenol	108-95-2	No	41100	173000	9.82×10^7	-	-	-
Phosphorus, White	7723-14-0	No	2.74	-	-	-	-	-
Polychlorinated Biphenyls	1336-36-3	No	-	-	-	6.08	15.4	27.8
Propyl benzene	103-65-1	No	13700	-	8430	-	-	-
Pyrene	129-00-0	No	4110	13300	-	-	-	-
Selenium	7782-49-2	No	684	-	9.82×10^6	-	-	-
Silver	7440-22-4	No	684	-	-	-	-	-
Styrene	100-42-5	No	27400	-	11400	-	-	-
TCDD, 2,3,7,8-	1746-01-6	No	0.0000958	0.00135	0.0867	0.0000936	0.00111	0.00154
Tetrachloroethane, 1,1,1,2-	630-20-6	No	4110	-	-	468	-	31.9
Tetrachloroethane, 1,1,2,2-	79-34-5	No	2740	-	-	60.8	-	10.3
Tetrachloroethylene	127-18-4	No	821	-	164	5790	-	424
Tetryl (Trinitrophenylmethylnitramine)	479-45-8	No	274	177000	-	-	-	-
Thallium (Soluble Salts)	7440-28-0	No	1.37	-	-	-	-	-
Toluene	108-88-3	No	11000	-	29000	-	-	-
Toxaphene	8001-35-2	No	-	-	-	11.1	39.3	41300
Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1	No	4.11×10^6	-	94800	-	-	-
Trichlorobenzene, 1,2,3-	87-61-6	No	110	-	-	-	-	-
Trichlorobenzene, 1,2,4-	120-82-1	No	1370	-	68.6	420	-	-
Trichloroethane, 1,1,1-	71-55-6	No	274000	-	16700	-	-	-
Trichloroethane, 1,1,2-	79-00-5	No	548	-	2.34	213	-	19.7
Trichloroethylene	79-01-6	Yes	68.4	-	7.95	154	-	18.2
Trichlorofluoromethane	75-69-4	No	41100	-	-	-	-	-
Trichlorophenol, 2,4,5-	95-95-4	No	13700	57700	-	-	-	-
Trichlorophenol, 2,4,6-	88-06-2	No	137	577	-	1110	3930	4.26×10^6
Trichlorophenoxyacetic Acid, 2,4,5-	93-76-5	No	1370	5770	-	-	-	-
Trichlorophenoxypropionic acid, -2,4,5	93-72-1	No	1100	4610	-	-	-	-

SOIL ARCTIC ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Trichloropropane, 1,2,3-	96-18-4	Yes	548	-	6.71	0.0893	-	-
Trimethylbenzene, 1,2,4-	95-63-6	No	-	-	67.2	-	-	-
Trimethylbenzene, 1,3,5-	108-67-8	No	1370	-	-	-	-	-
Tri-n-butyltin	688-73-3	No	41.1	-	-	-	-	-
Trinitrobenzene, 1,3,5-	99-35-4	No	4110	91100	-	-	-	-
Trinitrotoluene, 2,4,6-	118-96-7	No	68.4	901	-	406	4500	-
Vanadium and Compounds	7440-62-2	No	690	-	49100	-	-	-
Vinyl Acetate	108-05-4	No	137000	-	2130	-	-	-
Vinyl Chloride	75-01-4	Yes	411	-	226	0.981	-	2.34
Xylenes	1330-20-7	No	27400	-	729	-	-	-
Zinc and Compounds	7440-66-6	No	41100	-	-	-	-	-

[1] "CAS Number" means the Chemical Abstract Service (CAS) registry number uniquely assigned to chemicals by the American Chemical Society and recorded in the CAS Registry System
[2] "Ingestion" means a potential pathway of exposure to hazardous substances through direct consumption of the soil.
[3] "Dermal" means a potential pathway of exposure to hazardous substances through physical contact with the soil
[4] "Inhalation" means a potential pathway to volatile organic hazardous substances in the soil through volatilization.
[5] Cyanide expressed as free, or physiologically available cyanide

SOIL UNDER 40 INCH ZONE

SOIL UNDER 40 INCH ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[3]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Acenaphthene	83-32-9	No	6080	19700	-	-	-	-
Acenaphthylene	208-96-8	No	3040	9860	-	-	-	-
Acetone	67-64-1	No	91300	-	743000	-	-	-
Aldrin	309-00-2	No	3.04	-	-	0.530	-	7.15
Ammonium Perchlorate	7790-98-9	No	71.0	-	-	-	-	-
Anthracene	120-12-7	No	30400	98600	-	-	-	-
Antimony (metallic)	7440-36-0	No	40.6	-	-	-	-	-
Arsenic, Inorganic	7440-38-2	No	50.7	427	27600	10.0	71.2	11500
Barium	7440-39-3	No	20300	-	919000	-	-	-
Benz[a]anthracene	56-55-3	Yes	-	-	-	2.72	8.15	295
Benzaldehyde	100-52-7	No	10100	-	-	2250	-	-
Benzene	71-43-2	No	406	-	105	164	-	12.1
Benzo[a]pyrene	50-32-8	Yes	-	-	-	0.272	0.815	16200
Benzo[b]fluoranthene	205-99-2	Yes	-	-	-	2.72	8.15	162000
Benzo[g,h,i]perylene	191-24-2	No	3040	9860	-	-	-	-
Benzo[k]fluoranthene	207-08-9	Yes	-	-	-	27.2	81.5	162000
Benzoic Acid	65-85-0	No	406000	1.71×10^6	-	-	-	-
Benzyl Alcohol	100-51-6	No	10100	42700	-	-	-	-
Beryllium and compounds	7440-41-7	No	203	-	36800	-	-	20600
Bis(2-chloroethyl)ether	111-44-4	No	-	-	-	8.19	-	4.33
Bis(2-ethylhexyl)phthalate	117-81-7	No	2030	8550	-	644	2290	2.06×10^7
Bromobenzene	108-86-1	No	811	-	450	-	-	-
Bromodichloromethane	75-27-4	No	2030	-	-	145	-	3.73
Bromoform	75-25-2	No	2030	-	-	1140	-	300
Bromomethane	74-83-9	No	142	-	11.0	-	-	-
Butadiene, 1,3-	106-99-0	No	-	-	2.85	2.65	-	1.28
Butanol, N-	71-36-3	No	10100	-	-	-	-	-
Butyl Benzyl Phthlate	85-68-7	No	20300	85500	-	4740	16900	-
Butylbenzene, n-	104-51-8	No	5070	-	-	-	-	-
Butylbenzene, sec-	135-98-8	No	10100	-	-	-	-	-
Butylbenzene, tert-	98-06-6	No	10100	-	-	-	-	-
Cadmium (Diet)	7440-43-9	No	101	1070	18400	-	-	27500
Carbon Disulfide	75-15-0	No	10100	-	1250	-	-	-

SOIL UNDER 40 INCH ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[3]	Dermal[3]	Inhalation[4]	Ingestion[3]	Dermal[3]	Inhalation[4]
Carbon Tetrachloride	56-23-5	No	406	-	219	129	-	9.81
Chlordane	12789-03-6	No	50.7	534	812	25.7	229	312
Chlordecone (Kepone)	143-50-0	No	30.4	128	-	0.901	3.20	10800
Chloroaniline, p-	106-47-8	No	406	1710	-	45.1	160	-
Chlorobenzene	108-90-7	No	2030	-	290	-	-	-
Chloroform	67-66-3	No	1010	-	338	291	-	4.05
Chloromethane	74-87-3	No	-	-	168	-	-	-
Chloronaphthalene, Beta-	91-58-7	No	8110	26300	-	-	-	-
Chlorophenol, 2-	95-57-8	No	507	-	-	-	-	-
Chromium(III), Insoluble Salts	16065-83-1	No	152000	-	-	-	-	-
Chromium(VI)	18540-29-9	Yes	304	-	184000	3.97	-	213
Chrysene	218-01-9	Yes	-	-	-	272	815	1.62×10^6
Copper	7440-50-8	No	4060	-	-	-	-	-
Cresol, m-	108-39-4	No	5070	21400	1.10×10^9	-	-	-
Cresol, o-	95-48-7	No	5070	21400	1.10×10^9	-	-	-
Cresol, p-	106-44-5	No	10100	42700	1.10×10^9	-	-	-
Cumene	98-82-8	No	10100	-	2080	-	-	-
Cyanide (CN-)[5]	57-12-5	No	60.8	-	79.3	-	-	-
Cyclohexane	110-82-7	No	-	-	9440	-	-	-
DDD	72-54-8	No	-	-	-	37.6	133	717000
DDE, p,p'-	72-55-9	No	-	-	-	26.5	-	443
DDT	50-29-3	No	50.7	712	-	26.5	314	510000
Dibenz[a,h]anthracene	53-70-3	Yes	-	-	-	0.272	0.815	14900
Dibenzofuran	132-64-9	No	101	1420	-	-	-	-
Dibromochloromethane	124-48-1	No	2030	-	-	107	-	-
Dibromoethane, 1,2-	106-93-4	No	913	-	94.0	4.51	-	0.468
Dibromomethane (Methylene Bromide)	74-95-3	No	-	-	30.9	-	-	-
Dibutyl Phthalate	84-74-2	No	10100	42700	-	-	-	-
Dichlorobenzene, 1,2-	95-50-1	No	9130	-	1970	-	-	-
Dichlorobenzene, 1,3-	541-73-1	No	9130	-	1690	-	-	-
Dichlorobenzene, 1,4-	106-46-7	No	7100	-	7090	1670	-	21.7
Dichlorobenzidine, 3,3'-	91-94-1	No	-	-	-	20.0	71.2	146000
Dichlorodifluoromethane	75-71-8	No	20300	-	150	-	-	-
Dichloroethane, 1,1-	75-34-3	No	20300	-	-	1580	-	47.2
Dichloroethane, 1,2-	107-06-2	No	608	-	39.0	99.0	-	5.77

SOIL UNDER 40 INCH ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Dichloroethylene, 1,1-	75-35-4	No	5070	-	354	-	-	-
Dichloroethylene, 1,2-cis-	156-59-2	No	203	-	-	-	-	-
Dichloroethylene, 1,2-trans-	156-60-5	No	2030	-	-	-	-	-
Dichlorophenol, 2,4-	120-83-2	No	304	1280	-	-	-	-
Dichlorophenoxy Acetic Acid, 2,4-	94-75-7	No	1010	8550	-	-	-	-
Dichloropropane, 1,2-	78-87-5	No	9130	-	17.3	250	-	11.6
Dichloropropene, 1,3-	542-75-6	No	3040	-	78.9	90.1	-	26.6
Dieldrin	60-57-1	No	5.07	21.4	-	0.563	2.00	10800
Diethyl Phthalate	84-66-2	No	81100	342000	-	-	-	-
Dimethylphenol, 2,4-	105-67-9	No	2030	8550	-	-	-	-
Dimethylphthalate[5]	131-11-3	No	81100	342000	-	-	-	-
Dinitrobenzene, 1,2-	528-29-0	No	10.1	42.7	-	-	-	-
Dinitrobenzene, 1,3-	99-65-0	No	10.1	42.7	-	-	-	-
Dinitrobenzene, 1,4-	100-25-4	No	10.1	42.7	-	-	-	-
Dinitrophenol, 2,4-	51-28-5	No	203	855	-	-	-	-
Dinitrotoluene, 2,4-	121-14-2	No	203	838	-	29.1	101	556000
Dinitrotoluene, 2,6-	606-20-2	No	30.4	129	-	6.01	21.6	-
Dinitrotoluene, 2-Amino-4,6-	35572-78-2	No	203	14200	-	-	-	-
Dinitrotoluene, 4-Amino-2,6-	19406-51-0	No	203	9490	-	-	-	-
Dioxane, 1,4-	123-91-1	No	3040	-	2080	90.1	-	374
Diphenylamine	122-39-4	No	2530	10700	-	-	-	-
Endosulfan	115-29-7	No	608	-	-	-	-	-
Endrin	72-20-8	No	30.4	128	-	-	-	-
Ethyl Chloride	75-00-3	No	-	-	19500	-	-	-
Ethylbenzene	100-41-4	No	10100	-	4870	819	-	52.5
Ethylene Glycol	107-21-1	No	203000	855000	$7.35x\ 10^8$	-	-	-
Fluoranthene	206-44-0	No	4060	13100	-	-	-	-
Fluorene	86-73-7	No	4060	13100	-	-	-	-
Formaldehyde	50-00-0	No	20300	-	1390	-	-	292
Heptachlor	76-44-8	No	50.7	-	-	2.00	-	7.54
Heptachlor Epoxide	1024-57-3	No	1.32	-	-	0.990	-	6.65
Hexachlorobenzene	118-74-1	No	81.1	-	-	5.63	-	3.04
Hexachlorobutadiene	87-68-3	No	101	-	-	116	-	10.8
Hexachlorocyclohexane, Alpha-	319-84-6	No	811	3420	-	1.43	5.08	27500
Hexachlorocyclohexane, Beta-	319-85-7	No	-	-	-	5.01	17.8	93400

SOIL UNDER 40 INCH ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Hexachlorocyclohexane, Gamma- (Lindane)	58-89-9	No	30.4	320	-	8.19	72.8	160000
Hexachlorocyclopentadiene	77-47-4	No	608	-	1.40	-	-	-
Hexachloroethane	67-72-1	No	71.0	-	223	225	-	18.2
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	No	304	8550	-	81.9	1940	-
Hexane, N-	110-54-3	No	-	-	1050	-	-	-
Hexanone, 2-	591-78-6	No	507	-	578	-	-	-
Hydrazine	302-01-2	No	-	-	3.65	3.00	-	0.669
Indeno[1,2,3-cd]pyrene	193-39-5	Yes	-	-	-	2.72	8.15	162000
Isophorone	78-59-1	No	20300	85500	3.68×10^9	9490	33700	-
Isopropanol	67-63-0	No	203000	-	9940	-	-	-
Mercuric Chloride	7487-94-7	No	30.4	-	552000	-	-	-
Mercury (elemental)	7439-97-6	No	16.2	-	19.4	-	-	-
Methanol	67-56-1	No	203000	-	1.05×10^6	-	-	-
Methoxychlor	72-43-5	No	507	2140	-	-	-	-
Methyl Ethyl Ketone (2-Butanone)	78-93-3	No	60800	-	103000	-	-	-
Methyl Isobutyl Ketone (4-methyl-2-pentanone)	108-10-1	No	-	-	47300	-	-	-
Methyl Mercury	22967-92-6	No	10.1	-	-	-	-	-
Methyl tert-Butyl Ether (MTBE)	1634-04-4	No	-	-	22300	5010	-	771
Methylene Chloride	75-09-2	Yes	608	-	1850	993	-	3000
Methylnaphthalene, 1-	90-12-0	No	7100	23000	-	311	850	-
Methylnaphthalene, 2-	91-57-6	No	406	1310	-	-	-	-
Naphthalene	91-20-3	No	2030	6570	108	-	-	28.6
Nickel Soluble Salts	7440-02-0	No	2030	-	165000	-	-	190000
Nitrobenzene	98-95-3	No	203	-	580	-	-	43.4
Nitroglycerin	55-63-0	No	10.1	42.7	-	530	1880	-
Nitroguanidine	556-88-7	No	10100	42700	-	-	-	-
Nitrosodimethylamine, N-	62-75-9	Yes	0.811	-	4.41	0.0389	-	0.0766
Nitroso-di-N-propylamine, N-	621-64-7	No	-	-	-	1.29	4.58	24700
Nitrosodiphenylamine, N-	86-30-6	No	-	-	-	1840	6540	1.90×10^7
Nitrotoluene, m-	99-08-1	No	10.1	42.7	-	-	-	-
Nitrotoluene, o-	88-72-2	No	91.3	-	-	41.0	-	-
Nitrotoluene, p-	99-99-0	No	406	1710	-	563	2000	-

Sulfonate ACT

SOIL UNDER 40 INCH ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	No	5070	356000	-	-	-	-
Octyl Phthalate, di-N-	117-84-0	No	1010	4270	-	-	-	-
Pentachlorophenol	87-86-5	No	507	855	-	22.5	32.0	9.71×10^6
Pentaerythritol tetranitrate (PETN)	78-11-5	No	203	855	-	2250	8010	-
Perfluorooctane ~~Sulphonic Acid~~ (PFOS)	1763-23-1	No	2.03	8.55	-	-	-	-
Perfluorooctanoic Acid (PFOA)	335-67-1	No	2.03	8.55	-	129	458	-
Phenanthrene	85-01-8	No	3040	9860	-	-	-	-
Phenol	108-95-2	No	30400	128000	3.68×10^8	-	-	-
Phosphorus, White	7723-14-0	No	2.03	-	-	-	-	-
Polychlorinated Biphenyls	1336-36-3	No	-	-	-	4.51	11.4	19.0
Propyl benzene	103-65-1	No	10100	-	5760	-	-	-
Pyrene	129-00-0	No	3040	9860	-	-	-	-
Selenium	7782-49-2	No	507	-	3.68×10^7	-	-	-
Silver	7440-22-4	No	507	-	-	-	-	-
Styrene	100-42-5	No	20300	-	7820	-	-	-
TCDD, 2,3,7,8-	1746-01-6	No	0.0000710	0.000997	0.0595	0.0000693	0.000821	0.00105
Tetrachloroethane, 1,1,1,2-	630-20-6	No	3040	-	-	347	-	21.8
Tetrachloroethane, 1,1,2,2-	79-34-5	No	2030	-	-	45.1	-	7.07
Tetrachloroethylene	127-18-4	No	608	-	112	4290	-	290
Tetryl (Trinitrophenylmethylnitramine)	479-45-8	No	203	131000	-	-	-	-
Thallium (Soluble Salts)	7440-28-0	No	1.01	-	-	-	-	-
Toluene	108-88-3	No	8110	-	19800	-	-	-
Toxaphene	8001-35-2	No	-	-	-	8.19	29.1	155000
Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1	No	3.04×10^6	-	64800	-	-	-
Trichlorobenzene, 1,2,3-	87-61-6	No	81.1	-	-	-	-	-
Trichlorobenzene, 1,2,4-	120-82-1	No	1010	-	46.9	311	-	-
Trichloroethane, 1,1,1-	71-55-6	No	203000	-	11400	-	-	-
Trichloroethane, 1,1,2-	79-00-5	No	406	-	1.60	158	-	13.5
Trichloroethylene	79-01-6	Yes	50.7	-	5.44	114	-	12.5
Trichlorofluoromethane	75-69-4	No	30400	-	-	-	-	-
Trichlorophenol, 2,4,5-	95-95-4	No	10100	42700	-	-	-	-
Trichlorophenol, 2,4,6-	88-06-2	No	101	427	-	819	2910	1.60×10^7

SOIL UNDER 40 INCH ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Trichlorophenoxyacetic Acid, 2,4,5-	93-76-5	No	1010	4270	-	-	-	-
Trichlorophenoxypropionic acid, -2,4,5	93-72-1	No	811	3420	-	-	-	-
Trichloropropane, 1,2,3-	96-18-4	Yes	406	-	4.59	0.0662	-	-
Trimethylbenzene, 1,2,4-	95-63-6	No	-	-	45.9	-	-	-
Trimethylbenzene, 1,3,5-	108-67-8	No	1010	-	-	-	-	-
Tri-n-butyltin	688-73-3	No	30.4	-	-	-	-	-
Trinitrobenzene, 1,3,5-	99-35-4	No	3040	67500	-	-	-	-
Trinitrotoluene, 2,4,6-	118-96-7	No	50.7	668	-	300	3340	-
Vanadium and Compounds	7440-62-2	No	511	-	184000	-	-	-
Vinyl Acetate	108-05-4	No	101000	-	1460	-	-	-
Vinyl Chloride	75-01-4	Yes	304	-	155	0.962	-	2.04
Xylenes	1330-20-7	No	20300	-	498	-	-	-
Zinc and Compounds	7440-66-6	No	30400	-	-	-	-	-

[1] "CAS Number" means the Chemical Abstract Service (CAS) registry number uniquely assigned to chemicals by the American Chemical Society and recorded in the CAS Registry System
[2] "Ingestion" means a potential pathway of exposure to hazardous substances through direct consumption of the soil.
[3] "Dermal" means a potential pathway of exposure to hazardous substances through physical contact with the soil
[4] "Inhalation" means a potential pathway to volatile organic hazardous substances in the soil through volatilization.
[5] Cyanide expressed as free, or physiologically available cyanide

SOIL OVER 40 INCH ZONE

SOIL OVER 40 INCH ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic?	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Acenaphthene	83-32-9	No	4980	16100	-	-	-	-
Acenaphthylene	208-96-8	No	2490	8070	-	-	-	-
Acetone	67-64-1	No	74700	-	530000	-	-	-
Aldrin	309-00-2	No	2.49	-	-	0.434	-	5.10
Ammonium Perchlorate	7790-98-9	No	58.1	-	-	-	-	-
Anthracene	120-12-7	No	24900	80700	-	-	-	-
Antimony (metallic)	7440-36-0	No	33.2	-	-	-	-	-
Arsenic, Inorganic	7440-38-2	No	41.5	350	94700	8.19	58.2	39500
Barium	7440-39-3	No	16600	-	3.16×10^6	-	-	-
Benz[a]anthracene	56-55-3	Yes	-	-	-	2.23	6.67	211
Benzaldehyde	100-52-7	No	8300	-	-	1840	-	-
Benzene	71-43-2	No	332	-	74.9	134	-	8.62
Benzo[a]pyrene	50-32-8	Yes	-	-	-	0.223	0.667	55800
Benzo[b]fluoranthene	205-99-2	Yes	-	-	-	2.23	6.67	558000
Benzo[g,h,i]perylene	191-24-2	No	2490	8070	-	-	-	-
Benzo[k]fluoranthene	207-08-9	Yes	-	-	-	22.3	66.7	558000
Benzoic Acid	65-85-0	No	332000	1.40×10^6	-	-	-	-
Benzyl Alcohol	100-51-6	No	8300	35000	-	-	-	-
Beryllium and compounds	7440-41-7	No	166	-	126000	-	-	70800
Bis(2-chloroethyl)ether	111-44-4	No	-	-	-	6.70	-	3.09
Bis(2-ethylhexyl)phthalate	117-81-7	No	1660	6990	-	527	1870	7.08×10^7
Bromobenzene	108-86-1	No	664	-	321	-	-	-
Bromodichloromethane	75-27-4	No	1660	-	-	119	-	2.66
Bromoform	75-25-2	No	1660	-	-	933	-	214
Bromomethane	74-83-9	No	116	-	7.86	-	-	-
Butadiene, 1,3-	106-99-0	No	-	-	2.03	2.17	-	0.911
Butanol, N-	71-36-3	No	8300	-	-	-	-	-
Butyl Benzyl Phthlate	85-68-7	No	16600	69900	-	3880	13800	-
Butylbenzene, n-	104-51-8	No	4150	-	-	-	-	-
Butylbenzene, sec-	135-98-8	No	8300	-	-	-	-	-
Butylbenzene, tert-	98-06-6	No	8300	-	-	-	-	-
Cadmium (Diet)	7440-43-9	No	83.0	874	63200	-	-	94500
Carbon Disulfide	75-15-0	No	8300	-	894	-	-	-

SOIL OVER 40 INCH ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic?	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Carbon Tetrachloride	56-23-5	No	332	-	156	105	-	7.00
Chlordane	12789-03-6	No	41.5	437	579	21.1	187	223
Chlordecone (Kepone)	143-50-0	No	24.9	105	-	0.737	2.62	37000
Chloroaniline, p-	106-47-8	No	332	1400	-	36.9	131	-
Chlorobenzene	108-90-7	No	1660	-	207	-	-	-
Chloroform	67-66-3	No	830	-	241	238	-	2.89
Chloromethane	74-87-3	No	-	-	120	-	-	-
Chloronaphthalene, Beta-	91-58-7	No	6640	21500	-	-	-	-
Chlorophenol, 2-	95-57-8	No	415	-	-	-	-	-
Chromium(III), Insoluble Salts	16065-83-1	No	124000	-	-	-	-	-
Chromium(VI)	18540-29-9	Yes	249	-	632000	3.25	-	731
Chrysene	218-01-9	Yes	-	-	-	223	667	5.58×10^6
Copper	7440-50-8	No	3320	-	-	-	-	-
Cresol, m-	108-39-4	No	4150	17500	3.79×10^9	-	-	-
Cresol, o-	95-48-7	No	4150	17500	3.79×10^9	-	-	-
Cresol, p-	106-44-5	No	8300	35000	3.79×10^9	-	-	-
Cumene	98-82-8	No	8300	-	1480	-	-	-
Cyanide (CN-)[5]	57-12-5	No	49.8	-	56.5	-	-	-
Cyclohexane	110-82-7	No	-	-	6730	-	-	-
DDD	72-54-8	No	-	-	-	30.7	109	2.46×10^6
DDE, p,p'-	72-55-9	No	-	-	-	21.7	-	316
DDT	50-29-3	No	41.5	583	-	21.7	257	1.75×10^6
Dibenz[a,h]anthracene	53-70-3	Yes	-	-	-	0.223	0.667	51200
Dibenzofuran	132-64-9	No	83.0	1170	-	-	-	-
Dibromochloromethane	124-48-1	No	1660	-	-	87.8	-	-
Dibromoethane, 1,2-	106-93-4	No	747	-	67.0	3.69	-	0.334
Dibromomethane (Methylene Bromide)	74-95-3	No	-	-	22.0	-	-	-
Dibutyl Phthalate	84-74-2	No	8300	35000	-	-	-	-
Dichlorobenzene, 1,2-	95-50-1	No	7470	-	1410	-	-	-
Dichlorobenzene, 1,3-	541-73-1	No	7470	-	1200	-	-	-
Dichlorobenzene, 1,4-	106-46-7	No	5810	-	5060	1370	-	15.5
Dichlorobenzidine, 3,3'-	91-94-1	No	-	-	-	16.4	58.2	500000
Dichlorodifluoromethane	75-71-8	No	16600	-	107	-	-	-
Dichloroethane, 1,1-	75-34-3	No	16600	-	-	1290	-	33.7

SOIL OVER 40 INCH ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic?	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Dichloroethane, 1,2-	107-06-2	No	498	-	27.8	81.0	-	4.11
Dichloroethylene, 1,1-	75-35-4	No	4150	-	252	-	-	-
Dichloroethylene, 1,2-cis-	156-59-2	No	166	-	-	-	-	-
Dichloroethylene, 1,2-trans-	156-60-5	No	1660	-	-	-	-	-
Dichlorophenol, 2,4-	120-83-2	No	249	1050	-	-	-	-
Dichlorophenoxy Acetic Acid, 2,4-	94-75-7	No	830	6990	-	-	-	-
Dichloropropane, 1,2-	78-87-5	No	7470	-	12.3	205	-	8.28
Dichloropropene, 1,3-	542-75-6	No	2490	-	56.2	73.7	-	18.9
Dieldrin	60-57-1	No	4.15	17.5	-	0.461	1.64	37000
Diethyl Phthalate	84-66-2	No	66400	280000	-	-	-	-
Dimethylphenol, 2,4-	105-67-9	No	1660	6990	-	-	-	-
Dimethylphthalate	131-11-3	No	66400	280000	-	-	-	-
Dinitrobenzene, 1,2-	528-29-0	No	8.30	35.0	-	-	-	-
Dinitrobenzene, 1,3-	99-65-0	No	8.30	35.0	-	-	-	-
Dinitrobenzene, 1,4-	100-25-4	No	8.30	35.0	-	-	-	-
Dinitrophenol, 2,4-	51-28-5	No	166	699	-	-	-	-
Dinitrotoluene, 2,4-	121-14-2	No	166	685	-	23.8	82.9	1.91×10^{6}
Dinitrotoluene, 2,6-	606-20-2	No	24.9	106	-	4.92	17.6	-
Dinitrotoluene, 2-Amino-4,6-	35572-78-2	No	166	11700	-	-	-	-
Dinitrotoluene, 4-Amino-2,6-	19406-51-0	No	166	7770	-	-	-	-
Dioxane, 1,4-	123-91-1	No	2490	-	1480	73.7	-	266
Diphenylamine	122-39-4	No	2070	8740	-	-	-	-
Endosulfan	115-29-7	No	498	-	-	-	-	-
Endrin	72-20-8	No	24.9	105	-	-	-	-
Ethyl Chloride	75-00-3	No	-	-	13900	-	-	-
Ethylbenzene	100-41-4	No	8300	-	3470	670	-	37.4
Ethylene Glycol	107-21-1	No	166000	699000	2.53×10^{9}	-	-	-
Fluoranthene	206-44-0	No	3320	10800	-	-	-	-
Fluorene	86-73-7	No	3320	10800	-	-	-	-
Formaldehyde	50-00-0	No	16600	-	988	-	-	208
Heptachlor	76-44-8	No	41.5	-	-	1.64	-	5.38
Heptachlor Epoxide	1024-57-3	No	1.08	-	-	0.810	-	4.74
Hexachlorobenzene	118-74-1	No	66.4	-	-	4.61	-	2.17
Hexachlorobutadiene	87-68-3	No	83.0	-	-	94.5	-	7.73
Hexachlorocyclohexane, Alpha-	319-84-6	No	664	2800	-	1.17	4.16	94500

SOIL OVER 40 INCH ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic?	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Hexachlorocyclohexane, Beta-	319-85-7	No	-	-	-	4.10	14.6	321000
Hexachlorocyclohexane, Gamma- (Lindane)	58-89-9	No	24.9	262	-	6.70	59.6	549000
Hexachlorocyclopentadiene	77-47-4	No	498	-	1.00	-	-	-
Hexachloroethane	67-72-1	No	58.1	-	159	184	-	13.0
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	No	249	6990	-	67.0	1590	-
Hexane, N-	110-54-3	No	-	-	752	-	-	-
Hexanone, 2-	591-78-6	No	415	-	412	-	-	-
Hydrazine	302-01-2	No	-	-	2.60	2.46	-	0.477
Indeno[1,2,3-cd]pyrene	193-39-5	Yes	-	-	-	2.23	6.67	558000
Isophorone	78-59-1	No	16600	69900	1.26×10^{10}	7760	27600	-
Isopropanol	67-63-0	No	166000	-	7080	-	-	-
Mercuric Chloride	7487-94-7	No	24.9	-	1.89×10^{6}	-	-	-
Mercury (elemental)	7439-97-6	No	13.3	-	13.8	-	-	-
Methanol	67-56-1	No	166000	-	751000	-	-	-
Methoxychlor	72-43-5	No	415	1750	-	-	-	-
Methyl Ethyl Ketone (2-Butanone)	78-93-3	No	49800	-	73300	-	-	-
Methyl Isobutyl Ketone (4-methyl-2-pentanone)	108-10-1	No	-	-	33700	-	-	-
Methyl Mercury	22967-92-6	No	8.30	-	-	-	-	-
Methyl tert-Butyl Ether (MTBE)	1634-04-4	No	-	-	15900	4100	-	550
Methylene Chloride	75-09-2	Yes	498	-	1320	812	-	2140
Methylnaphthalene, 1-	90-12-0	No	5810	18800	-	254	695	-
Methylnaphthalene, 2-	91-57-6	No	332	1080	-	-	-	-
Naphthalene	91-20-3	No	1660	5380	77.3	-	-	20.4
Nickel Soluble Salts	7440-02-0	No	1660	-	568000	-	-	654000
Nitrobenzene	98-95-3	No	166	-	413	-	-	30.9
Nitroglycerin	55-63-0	No	8.30	35.0	-	434	1540	-
Nitroguanidine	556-88-7	No	8300	35000	-	-	-	-
Nitrosodimethylamine, N-	62-75-9	Yes	0.664	-	3.14	0.0318	-	0.0546
Nitroso-di-N-propylamine, N-	621-64-7	No	-	-	-	1.05	3.74	85000
Nitrosodiphenylamine, N-	86-30-6	No	-	-	-	1500	5350	6.54×10^{7}
Nitrotoluene, m-	99-08-1	No	8.30	35.0	-	-	-	-
Nitrotoluene, o-	88-72-2	No	74.7	-	-	33.5	-	-
Nitrotoluene, p-	99-99-0	No	332	1400	-	461	1640	-

Sulfonate XCT

SOIL OVER 40 INCH ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic?	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	No	4150	291000	-	-	-	-
Octyl Phthalate, di-N-	117-84-0	No	830	3500	-	-	-	-
Pentachlorophenol	87-86-5	No	415	699	-	18.4	26.2	3.33×10^7
Pentaerythritol tetranitrate (PETN)	78-11-5	No	166	699	-	1840	6550	-
Perfluorooctane ~~Sulphonic Acid~~ (PFOS)	1763-23-1	No	1.66	6.99	-	-	-	-
Perfluorooctanoic Acid (PFOA)	335-67-1	No	1.66	6.99	-	105	374	-
Phenanthrene	85-01-8	No	2490	8070	-	-	-	-
Phenol	108-95-2	No	24900	105000	1.26×10^9	-	-	-
Phosphorus, White	7723-14-0	No	1.66	-	-	-	-	-
Polychlorinated Biphenyls	1336-36-3	No	-	-	-	3.69	9.36	13.6
Propyl benzene	103-65-1	No	8300	-	4110	-	-	-
Pyrene	129-00-0	No	2490	8070	-	-	-	-
Selenium	7782-49-2	No	415	-	1.26×10^8	-	-	-
Silver	7440-22-4	No	415	-	-	-	-	-
Styrene	100-42-5	No	16600	-	5580	-	-	-
TCDD, 2,3,7,8-	1746-01-6	No	0.0000581	0.000816	0.0425	0.0000567	0.000672	0.000752
Tetrachloroethane, 1,1,1,2-	630-20-6	No	2490	-	-	284	-	15.6
Tetrachloroethane, 1,1,2,2-	79-34-5	No	1660	-	-	36.9	-	5.04
Tetrachloroethylene	127-18-4	No	498	-	79.9	3510	-	207
Tetryl (Trinitrophenylmethylnitramine)	479-45-8	No	166	108000	-	-	-	-
Thallium (Soluble Salts)	7440-28-0	No	0.830	-	-	-	-	-
Toluene	108-88-3	No	6640	-	14100	-	-	-
Toxaphene	8001-35-2	No	-	-	-	6.70	23.8	531000
Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1	No	2.49×10^6	-	46200	-	-	-
Trichlorobenzene, 1,2,3-	87-61-6	No	66.4	-	-	-	-	-
Trichlorobenzene, 1,2,4-	120-82-1	No	830	-	33.4	254	-	-
Trichloroethane, 1,1,1-	71-55-6	No	166000	-	8160	-	-	-
Trichloroethane, 1,1,2-	79-00-5	No	332	-	1.14	129	-	9.59
Trichloroethylene	79-01-6	Yes	41.5	-	3.88	93.1	-	8.89
Trichlorofluoromethane	75-69-4	No	24900	-	-	-	-	-
Trichlorophenol, 2,4,5-	95-95-4	No	8300	35000	-	-	-	-

SOIL OVER 40 INCH ZONE			Non-Carcinogenic (mg/kg)			Carcinogenic (mg/kg)		
Hazardous Substance	CAS Number[1]	Mutagenic?	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Trichlorophenol, 2,4,6-	88-06-2	No	83.0	350	-	670	2380	5.49×10^7
Trichlorophenoxyacetic Acid, 2,4,5-	93-76-5	No	830	3500	-	-	-	-
Trichlorophenoxypropionic acid, - 2,4,5	93-72-1	No	664	2800	-	-	-	-
Trichloropropane, 1,2,3-	96-18-4	Yes	332	-	3.27	0.0541	-	-
Trimethylbenzene, 1,2,4-	95-63-6	No	-	-	32.7	-	-	-
Trimethylbenzene, 1,3,5-	108-67-8	No	830	-	-	-	-	-
Tri-n-butyltin	688-73-3	No	24.9	-	-	-	-	-
Trinitrobenzene, 1,3,5-	99-35-4	No	2490	55200	-	-	-	-
Trinitrotoluene, 2,4,6-	118-96-7	No	41.5	546	-	246	2730	-
Vanadium and Compounds	7440-62-2	No	418	-	632000	-	-	-
Vinyl Acetate	108-05-4	No	83000	-	1040	-	-	-
Vinyl Chloride	75-01-4	Yes	249	-	110	0.945	-	1.69
Xylenes	1330-20-7	No	16600	-	355	-	-	-
Zinc and Compounds	7440-66-6	No	24900	-	-	-	-	-

[1] "CAS Number" means the Chemical Abstract Service (CAS) registry number uniquely assigned to chemicals by the American Chemical Society and recorded in the CAS Registry System

[2] "Ingestion" means a potential pathway of exposure to hazardous substances through direct consumption of the soil.

[3] "Dermal" means a potential pathway of exposure to hazardous substances through physical contact with the soil

[4] "Inhalation" means a potential pathway to volatile organic hazardous substances in the soil through volatilization.

[5] Cyanide expressed as free, or physiologically available cyanide

GROUNDWATER

GROUNDWATER			Non-Carcinogenic (µg/L)			Carcinogenic (µg/L)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Acenaphthene	83-32-9	No	1200	963	-	-	-	-
Acenaphthylene	208-96-8	No	602	461	-	-	-	-
Acetone	67-64-1	No	18000	4.39×10^6	64400	-	-	-
Aldrin	309-00-2	No	0.602	-	-	0.0458	-	0.0115
Ammonium Perchlorate	7790-98-9	No	14.0	3190	-	-	-	-
Anthracene	120-12-7	No	6020	2500	-	-	-	-
Antimony (metallic)	7440-36-0	No	8.02	273	-	-	-	-
Arsenic, Inorganic	7440-38-2	No	6.02	1370	-	0.519	97.3	-
Barium	7440-39-3	No	4010	63700	-	-	-	-
Benz[a]anthracene	56-55-3	Yes	-	-	-	0.343	-	0.184
Benzaldehyde	100-52-7		2010	49100	-	195	4390	-
Benzene	71-43-2	No	80.2	605	62.6	14.2	98.3	7.20
Benzo[a]pyrene	50-32-8	Yes	-	-	-	0.0343	-	-
Benzo[b]fluoranthene	205-99-2	Yes	-	-	-	0.343	-	-
Benzo[g,h,i]perylene	191-24-2	No	602	-	-	-	-	-
Benzo[k]fluoranthene	207-08-9	Yes	-	-	-	3.43	-	-
Benzoic Acid	65-85-0	No	80200	1.20×10^6	-	-	-	-
Benzyl Alcohol	100-51-6	No	2010	88900	-	-	-	-
Beryllium and compounds	7440-41-7	No	40.1	63.7	-	-	-	-
Bis(2-chloroethyl)ether	111-44-4	No	-	-	-	0.708	27.1	0.170
Bis(2-ethylhexyl)phthalate	117-81-7	No	401	-	-	55.6	-	-
Bromobenzene	108-86-1	No	160	542	125	-	-	-
Bromodichloromethane	75-27-4	No	401	6460	-	12.6	186	1.52
Bromoform	75-25-2	No	401	6230	-	98.6	1410	51.0
Bromomethane	74-83-9	No	28.1	997	10.4	-	-	-
Butadiene, 1,3-	106-99-0	No	-	-	4.17	0.229	1.62	1.87
Butanol, N-	71-36-3	No	2010	100000	-	-	-	-
Butyl Benzyl Phthlate	85-68-7	No	4010	2870	-	410	270	-
Butylbenzene, n-	104-51-8	No	1000	-	-	-	-	-
Butylbenzene, sec-	135-98-8	No	2010	-	-	-	-	-
Butylbenzene, tert-	98-06-6	No	2010	1050	-	-	-	-
Cadmium (Diet)	7440-43-9	No	10.0	114	-	-	-	-
Carbon Disulfide	75-15-0	No	2010	20000	1460	-	-	-

GROUNDWATER			Non-Carcinogenic (µg/L)			Carcinogenic (µg/L)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Carbon Tetrachloride	56-23-5	No	80.2	340	209	11.1	43.3	9.36
Chlordane	12789-03-6	No	10.0	1.77	1.46	2.23	0.362	0.562
Chlordecone (Kepone)	143-50-0	No	6.02	5.43	-	0.0779	0.0647	-
Chloroaniline, p-	106-47-8	No	80.2	1320	-	3.90	59.0	-
Chlorobenzene	108-90-7	No	401	1280	104	-	-	-
Chloroform	67-66-3	No	201	2530	204	25.1	292	2.44
Chloromethane	74-87-3	No	-	-	188	-	-	-
Chloronaphthalene, Beta-	91-58-7	No	1600	1400	-	-	-	-
Chlorophenol, 2-	95-57-8	No	100	1020	-	-	-	-
Chromium(III), Insoluble Salts	16065-83-1	No	30100	88700	-	-	-	-
Chromium(VI)	18540-29-9	Yes	60.2	171	-	0.501	1.16	-
Chrysene	218-01-9	Yes	-	-	-	34.3	-	-
Copper	7440-50-8	No	802	182000	-	-	-	-
Cresol, m-	108-39-4	No	1000	12000	-	-	-	-
Cresol, o-	95-48-7	No	1000	12100	-	-	-	-
Cresol, p-	106-44-5	No	2010	24600	-	-	-	-
Cumene	98-82-8	No	2010	1920	834	-	-	-
Cyanide (CN-)	57-12-5	No	12.0	2730	1.67	-	-	-
Cyclohexane	110-82-7	No	-	-	12500	-	-	-
DDD	72-54-8	No	-	-	-	3.25	0.351	-
DDE, p,p'-	72-55-9	No	-	-	-	2.29	-	0.579
DDT	50-29-3	No	10.0	-	-	2.29	-	-
Dibenz[a,h]anthracene	53-70-3	Yes	-	-	-	0.0343	-	-
Dibenzofuran	132-64-9	No	20.1	12.9	-	-	-	-
Dibromochloromethane	124-48-1	No	401	6740	-	9.27	143	-
Dibromoethane, 1,2-	106-93-4	No	180	3600	18.8	0.390	7.14	0.0936
Dibromomethane (Methylene Bromide)	74-95-3	No	-	-	8.34	-	-	-
Dibutyl Phthalate	84-74-2	No	2010	1640	-	-	-	-
Dichlorobenzene, 1,2-	95-50-1	No	1800	2920	417	-	-	-
Dichlorobenzene, 1,3-[5]	541-73-1	No	1800	2500	417	-	-	-
Dichlorobenzene, 1,4-	106-46-7	No	1400	2230	1670	144	211	5.10
Dichlorobenzidine, 3,3'-	91-94-1	No	-	-	-	1.73	4.53	-
Dichlorodifluoromethane	75-71-8	No	4010	38200	209	-	-	-
Dichloroethane, 1,1-	75-34-3	No	4010	58400	-	137	1830	35.1
Dichloroethane, 1,2-	107-06-2	No	120	2820	14.6	8.56	184	2.16

GROUNDWATER			Non-Carcinogenic (µg/L)			Carcinogenic (µg/L)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Dichloroethylene, 1,1-	75-35-4	No	1000	8540	417	-	-	-
Dichloroethylene, 1,2-cis-	156-59-2	No	40.1	363	-	-	-	-
Dichloroethylene, 1,2-trans-	156-60-5	No	401	3630	-	-	-	-
Dichlorophenol, 2,4-	120-83-2	No	60.2	190	-	-	-	-
Dichlorophenoxy Acetic Acid, 2,4-	94-75-7	No	201	1350	-	-	-	-
Dichloropropane, 1,2-	78-87-5	No	1800	21500	8.34	21.6	237	5.62
Dichloropropene, 1,3-	542-75-6	No	602	6560	41.7	7.79	78.2	14.0
Dieldrin	60-57-1	No	1.00	0.614	-	0.0487	0.0274	-
Diethyl Phthalate	84-66-2	No	16000	198000	-	-	-	-
Dimethylphenol, 2,4-	105-67-9	No	401	3110	-	-	-	-
Dimethylphthalate[5]	131-11-3	No	16000	581000	-	-	-	-
Dinitrobenzene, 1,2-	528-29-0	No	2.01	53.3	-	-	-	-
Dinitrobenzene, 1,3-	99-65-0	No	2.01	72.5	-	-	-	-
Dinitrobenzene, 1,4-	100-25-4	No	2.01	75.6	-	-	-	-
Dinitrophenol, 2,4-	51-28-5	No	40.1	1220	-	-	-	-
Dinitrotoluene, 2,4-	121-14-2	No	40.1	749	-	2.51	43.2	-
Dinitrotoluene, 2,6-	606-20-2	No	6.02	93.5	-	0.519	7.42	-
Dinitrotoluene, 2-Amino-4,6-	35572-78-2	No	40.1	1030	-	-	-	-
Dinitrotoluene, 4-Amino-2,6-	19406-51-0	No	40.1	1030	-	-	-	-
Dioxane, 1,4-	123-91-1	No	602	191000	62.6	7.79	2280	11.2
Diphenylamine	122-39-4	No	501	840	-	-	-	-
Endosulfan	115-29-7	No	120	631	-	-	-	-
Endrin	72-20-8	No	6.02	3.68	-	-	-	-
Ethyl Chloride	75-00-3	No	-	-	20900	-	-	-
Ethylbenzene	100-41-4	No	2010	3820	2090	70.8	124	22.5
Ethylene Glycol	107-21-1	No	40100	5.70×10^7	-	-	-	-
Fluoranthene	206-44-0	No	802	-	-	-	-	-
Fluorene	86-73-7	No	802	465	-	-	-	-
Formaldehyde	50-00-0	No	4010	318000	20.5	-	-	4.32
Heptachlor	76-44-8	No	10.0	1.47	-	0.173	0.0233	0.0432
Heptachlor Epoxide	1024-57-3	No	0.261	0.236	-	0.0856	0.0712	0.0216
Hexachlorobenzene	118-74-1	No	16.0	-	-	0.487	-	0.122
Hexachlorobutadiene	87-68-3	No	20.1	9.53	-	9.99	4.36	2.55
Hexachlorocyclohexane, Alpha-	319-84-6	No	160	247	-	0.124	0.175	-
Hexachlorocyclohexane, Beta-	319-85-7	No	-	-	-	0.433	0.613	-

GROUNDWATER			Non-Carcinogenic (µg/L)			Carcinogenic (µg/L)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Hexachlorocyclohexane, Gamma- (Lindane)	58-89-9	No	6.02	9.26	-	0.708	1.00	-
Hexachlorocyclopentadiene	77-47-4	No	120	41.6	0.417	-	-	-
Hexachloroethane	67-72-1	No	14.0	13.7	62.6	19.5	17.5	5.10
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	No	60.2	7960	-	7.08	861	-
Hexane, N-	110-54-3	No	-	-	1460	-	-	-
Hexanone, 2-	591-78-6	No	100	2760	62.6	-	-	-
Hydrazine[7]	302-01-2	No	-	-	0.0626	0.260	1120	0.0115
Indeno[1,2,3-cd]pyrene	193-39-5	Yes	-	-	-	0.343	-	-
Isophorone	78-59-1	No	4010	86500	-	820	16300	-
Isopropanol	67-63-0	No	40100	6.51×10^6	417	-	-	-
Mercuric Chloride	7487-94-7	No	6.02	95.6	-	-	-	-
Mercury (elemental)	7439-97-6	No	3.21	728	0.626	-	-	-
Methanol	67-56-1	No	40100	1.80×10^7	41700	-	-	-
Methoxychlor	72-43-5	No	100	58.7	-	-	-	-
Methyl Ethyl Ketone (2-Butanone)	78-93-3	No	12000	1.46×10^6	10400	-	-	-
Methyl Isobutyl Ketone (4-methyl-2-pentanone)	108-10-1	No	-	-	6260	-	-	-
Methyl Mercury	22967-92-6	No	2.01	455	-	-	-	-
Methyl tert-Butyl Ether (MTBE)	1634-04-4	No	-	-	6260	433	19900	216
Methylene Chloride	75-09-2	Yes	120	3660	1250	125	3470	2030
Methylnaphthalene, 1-	90-12-0	No	1400	1120	-	26.9	19.7	-
Methylnaphthalene, 2-	91-57-6	No	80.2	65.1	-	-	-	-
Naphthalene	91-20-3	No	401	701	6.26	-	-	1.65
Nickel Soluble Salts	7440-02-0	No	401	18200	-	-	-	-
Nitrobenzene	98-95-3	No	40.1	624	18.8	-	-	1.40
Nitroglycerin	55-63-0	No	2.01	86.8	-	45.8	1820	-
Nitroguanidine	556-88-7	No	2010	1.82×10^6	-	-	-	-
Nitrosodimethylamine, N-	62-75-9	Yes	0.160	73.8	0.0834	0.00491	2.00	0.00145
Nitroso-di-N-propylamine, N-	621-64-7	No	-	-	-	0.111	3.53	-
Nitrosodiphenylamine, N-	86-30-6	No	-	-	-	159	523	-
Nitrotoluene, m-	99-08-1	No	2.01	13.6	-	-	-	-
Nitrotoluene, o-	88-72-2	No	18.0	154	-	3.54	27.8	-
Nitrotoluene, p-	99-99-0	No	80.2	617	-	48.7	344	-

Sulfonate XCDT

GROUNDWATER			Non-Carcinogenic (µg/L)			Carcinogenic (µg/L)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[3]	Dermal[3]	Inhalation[4]	Ingestion[3]	Dermal[3]	Inhalation[4]
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	No	1000	634000	-	-	-	-
Octyl Phthalate, di-N-	117-84-0	No	201	-	-	-	-	-
Pentachlorophenol	87-86-5	No	100	29.3	-	1.95	0.524	-
Pentaerythritol tetranitrate (PETN)	78-11-5	No	40.1	962	-	195	4300	-
Perfluorooctane ~~Sulphonic Acid~~ (PFOS)	1763-23-1	No	0.401	-	-	-	-	-
Perfluorooctanoic Acid (PFOA)	335-67-1	No	0.401	-	-	11.1	-	-
Phenanthrene	85-01-8	No	602	246	-	-	-	-
Phenol	108-95-2	No	6020	141000	-	-	-	-
Phosphorus, White	7723-14-0	No	0.401	91.0	-	-	-	-
Polychlorinated Biphenyls	1336-36-3	No	-	-	-	1.95	-	0.562
Propyl benzene	103-65-1	No	2010	1830	2090	-	-	-
Pyrene	129-00-0	No	602	151	-	-	-	-
Selenium	7782-49-2	No	100	22800	-	-	-	-
Silver	7440-22-4	No	100	1520	-	-	-	-
Styrene	100-42-5	No	4010	10300	2090	-	-	-
TCDD, 2,3,7,8-	1746-01-6	No	0.0000140	-	0.0000834	5.99×10^{-6}	-	1.48×10^{-6}
Tetrachloroethane, 1,1,1,2-	630-20-6	No	602	2390	-	30.0	109	7.59
Tetrachloroethane, 1,1,2,2-	79-34-5	No	401	3640	-	3.90	32.5	0.968
Tetrachloroethylene	127-18-4	No	120	230	83.4	371	653	216
Tetryl (Trinitrophenylmethylnitramine)	479-45-8	No	40.1	2470	-	-	-	-
Thallium (Soluble Salts)	7440-28-0	No	0.201	45.5	-	-	-	-
Toluene	108-88-3	No	1600	5300	10400	-	-	-
Toxaphene	8001-35-2	No	-	-	-	0.708	-	-
Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1	No	602000	1.91×10^{6}	62600	-	-	-
Trichlorobenzene, 1,2,3-	87-61-6	No	16.0	12.6	-	-	-	-
Trichlorobenzene, 1,2,4-	120-82-1	No	201	164	4.17	26.9	20.2	-
Trichloroethane, 1,1,1-	71-55-6	No	40100	251000	10400	-	-	-
Trichloroethane, 1,1,2-	79-00-5	No	80.2	1250	0.417	13.7	196	3.51
Trichloroethylene	79-01-6	Yes	10.0	68.9	4.17	11.8	74.5	9.57
Trichlorofluoromethane	75-69-4	No	6020	36400	-	-	-	-
Trichlorophenol, 2,4,5-	95-95-4	No	2010	2890	-	-	-	-
Trichlorophenol, 2,4,6-	88-06-2	No	20.1	30.2	-	70.8	98.1	-

GROUNDWATER			Non-Carcinogenic (µg/L)			Carcinogenic (µg/L)		
Hazardous Substance	CAS Number[1]	Mutagenic[2]	Ingestion[2]	Dermal[3]	Inhalation[4]	Ingestion[2]	Dermal[3]	Inhalation[4]
Trichlorophenoxyacetic Acid, 2,4,5-	93-76-5	No	201	874	-	-	-	-
Trichlorophenoxypropionic acid, -2,4,5	93-72-1	No	160	362	-	-	-	-
Trichloropropane, 1,2,3-	96-18-4	Yes	80.2	767	0.626	0.00835	0.0728	-
Trimethylbenzene, 1,2,4-	95-63-6	No	-	-	14.6	-	-	-
Trimethylbenzene, 1,3,5-	108-67-8	No	201	277	-	-	-	-
Tri-n-butyltin	688-73-3	No	6.02	9.87	-	-	-	-
Trinitrobenzene, 1,3,5-	99-35-4	No	602	46700	-	-	-	-
Trinitrotoluene, 2,4,6-	118-96-7	No	10.0	448	-	26.0	1070	-
Vanadium and Compounds	7440-62-2	No	101	596	-	-	-	-
Vinyl Acetate	108-05-4	No	20100	1.36×10^6	417	-	-	-
Vinyl Chloride	75-01-4	Yes	60.2	893	209	0.214	2.77	3.35
Xylenes	1330-20-7	No	4010	7530	209	-	-	-
Zinc and Compounds	7440-66-6	No	6020	2.28×10^6	-	-	-	-

[1] "CAS Number" means the Chemical Abstract Service (CAS) registry number uniquely assigned to chemicals by the American Chemical Society and recorded in the CAS Registry System
[2] "Ingestion" means a potential pathway of exposure to hazardous substances through direct consumption of the soil.
[3] "Dermal" means a potential pathway of exposure to hazardous substances through physical contact with the soil
[4] "Inhalation" means a potential pathway to volatile organic hazardous substances in the soil through volatilization.

APPENDIX C: HIERARCHY OF TOXICITY SOURCES AND MCLS

Hierarchy of Toxicity Sources and MCLs
Alaska Department of Environmental Conservation
Division of Spill Prevention and Response
Contaminated Sites Program

Tier I Source = IRIS- Integrated Risk Information System
IRIS is EPA's data base containing qualitative and quantitative information on the human health effects that may result from exposure to chemical substances in the environment. The toxicity values listed in IRIS are considered to be validated and have undergone rigorous peer review. The completion of IRIS assessments is a multi-step process:

1) EPA Develops and Completes a draft IRIS Toxicological Review (Duration 345 Days)
2) Internal EPA Review (Duration 60 days)
3) EPA Initiates Interagency Science Consultation on Draft IRIS Toxicological Review (Duration 45 days)
4) EPA Initiates Independent External Peer Review of Draft IRIS Toxicological Review, Public Review and Comment on Draft IRIS Toxicological Review, and Holds a Public Listening Session (Duration 105 days)
5) EPA Revises IRIS Toxicological Review and Develops IRIS Summary (Duration 60 days)
6) (A) Internal EPA Review of Final IRIS Toxicological Review and IRIS Summary (Duration 45 days)
   (B) EPA-led Interagency Science Discussion (Duration 45 days – concurrent with Step 6A.)
7) EPA Completion of IRIS Toxicological Review and IRIS Summary (Duration 30 days)

Tier II Source = PPRTV- Provisional Peer Reviewed Toxicity Values
The Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center develops PPRTVs on a chemical-specific basis when requested by the EPA's Superfund program for use in site specific risk assessments. However, the PPRTVs are developed in a shorter period of time and although these assessments undergo external peer review, their development does not include Agency and interagency review as is done with the IRIS assessments. Furthermore, their development typically includes a limited evaluation of information on mode of action, other toxicological end points, and other information that provides a better understanding of the toxicology of these chemicals. Often, the amount of relevant information on the toxicity of these chemicals is less because fewer studies have been conducted and reported. However, the PPRTVs are generally the best quantification of the dose-response scientific data that is available at the time they are developed because the PPRTVs utilize current information and methodologies.

Tier III Source = Other Toxicity Values
Tier 3 includes additional EPA/non-EPA sources of toxicity information. Chemicals that have not been through a rigorous IRIS process or requested for PPRTV listing can contain toxicity recommend values from other sources. Priority should be given to sources of information that are most current, peer reviewed, transparent and publicly available. The quality of these values can vary widely and depends on the depth of the toxicity data base, the scientific quality and rigor of the underlying risk assessment and the scope of peer review. Some available values, such as Agency for

Toxic Substances and Disease Registry (ATSDR) Minimal Risk Level (MRLs) and California Environmental Protection Agency (Cal EPA) criteria, have undergone an extensive literature review, a rigorous data analysis using current guidance and methods to derive a toxicity value, and have been thoroughly peer reviewed. It should be noted that ATSDR MRLs are limited to non-cancer effects only. At the other end of the spectrum, there may be chemicals with no values and little or no available toxicity information, or outdated studies which are no longer consistent with current methodologies and practices.

Maximum Contaminant Levels (MCLs) are standards that are set by the United States EPA for drinking water quality. An MCL is the legal threshold limit on the amount of a substance that is allowed in public water systems under the Safe Drinking Water Act. To set a MCL for a contaminant, EPA first determines how much of the contaminant may be present with no adverse health effects based on the information from hierarchy of toxicity listed above. This level is called the Maximum Contaminant Level Goal (MCLG). MCLGs are non-enforceable public health goals. The legally enforced MCL is then set as close as possible to the MCLG. The MCL for a contaminant may be higher than the MCLG because of difficulties in measuring small quantities of a contaminant, a lack of available treatment technologies, or if EPA determines that the costs of treatment would outweigh the public health benefits of a lower MCL. In the last case, EPA will set the MCL to balance the cost of treatment with the public health benefits.
The EPA guidance for establishing an MCL states that "MCLs are enforceable standards and are to be set as close to the maximum contaminant level goals (MCLGs) (Health Goals) as is feasible and are based upon treatment technologies, costs (affordability) and other feasibility factors, such as availability of analytical methods, treatment technology and costs for achieving various levels of removal." The process of determining an MCL only starts with an evaluation of the adverse effects caused by the chemical in question and the doses needed to cause such effects. Finally, only a very small percentage of environmental contaminants have an established MCL.