NEW MEXICO ENVIRONMENT DEPARTMENT

Risk Assessment Guidance for Site Investigations and Remediation

Volume I
Soil Screening Guidance for Human Health Risk Assessments

November 2021

EXECUTIVE SUMMARY

This guidance document is being developed in coordination with the New Mexico Environment Department's (NMED) Hazardous Waste Bureau (HWB) and the Ground Water Quality Bureau.

This guidance document sets forth recommended approaches based on current State and Federal practices and intended for used as guidance for employees of NMED and for facilities within the State of New Mexico.

In the past, the material contained within this document existed in multiple guidance and/or position papers. In order to streamline the risk assessment process and ensure consistency between guidance/position papers, these documents have been combined into one document: *Risk Assessment Guidance for Site Investigations and Remediation*.

The *Risk Assessment Guidance for Site Investigations and Remediation* dated December 2018 replaces and supersedes previous versions of this document as well as the following documents:

- *Technical Background Document for Development of Soil Screening Levels*, Revision 6.0, 2012,
- *New Mexico Environment Department TPH Screening Guidelines*, October 2006, and
- *Risk-Based Remediation of Polychlorinated Biphenyls at RCRA Corrective Action Sites*, NMED Position Paper, March 2000.
- *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment*, March 2000 and 2008.

This *Risk Assessment Guidance for Site Investigations and Remediation* is organized into two volumes.

- Volume I –Soil Screening Guidance for Human Health Risk Assessments
- Volume II - Soil Screening Guidance for Ecological Risk Assessments

Volume I presents information related to conducting screening level human health risk assessments. Previously, the soil screening levels (SSLs) were available in the *Technical Background Document for Development of Soil Screening Levels* while the screening levels for total petroleum hydrocarbons (TPH) were found in the *New Mexico Environment Department TPH Screening Guidelines*. Now both are contained in Volume I. Volume I also includes SSLs for select Aroclors, congeners of polychlorinated biphenyls (PCBs), total petroleum hydrocarbons (TPH), and chemicals of emerging concern.

Volume II provides guidance for conducting ecological risk assessments and contains guidance that was previously contained in the *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment*, March 2008.

SUMMARY OF CHANGES

The following table summarizes changes to the "Risk Assessment Guidance for Investigations and Remediation," Volume I. Specific changes are as follows:

VOLUME I SOIL SCREENING GUIDANCE FOR HUMAN HEALTH RISK ASSESSMENTS		
Item	**Section**	**Change**
November 2014		
1	Global	Update default exposure parameters; includes changes to text, tables, equations, and soil screening levels in Appendix A
2	Global	General edits and clarifications
3	Table of Acronyms	Updated
4	Table of Contents	Updated
5	Summary of Changes	Added new section summarizing changes to document by revision number and date
6	Section 1.2.1 and Table 1-1	Addition of tap-water exposure, vapor intrusion and beef ingestion pathways
7	Section 2.1	Additional chemical-specific information added for clarification. Includes changes or additions to dioxin/furans, polychlorinated biphenyls (PCBs), hexavalent and total chromium, vanadium, xylene, phenanthrene, and polycyclic aromatic hydrocarbons (PAHs).
8	Section 2.1.7	Section added addressing emerging contaminants
9	Section 2.2.1 and Equations 12-17	Incorporated carcinogenic and mutagenic effects to calculation of trichloroethylene (TCE) specific soil screening levels
10	Section 2.4	Modified to include dermal exposure
11	Equations 24-26	Equations were modified and added to include dermal contact with tap water pathway
12	Equation 27	Changed noncarcinogenic exposure parameters from adult exposure to child exposure (tap water)
13	Equations 29-30 and Equations 31-35	Added dermal pathway to equations for vinyl chloride and mutagens
14	Section 2.5	Section added addressing the vapor intrusion pathway and derivation of vapor screening levels
15	Section 2.6	Section added describing the evaluation of the beef ingestion pathway
16	Section 2.7.2	Section added describing background threshold values
17	Section 2.7.3	Clarification added on determination of constituents of potential concern
18	Section 2.7.7	Section added providing guidance for calculation of exposure-point concentrations
19	Section 3.4	Added list of sources used for deriving chemical property information

20	Section 5.0	Clarification added to text on the use of the SSLs
21	Section 5.1	Section added describing chromium speciation and tiered approach to using chromium screening levels
22	Section 5.2	Section added describing derivation of screening levels for essential nutrients
23	Section 6.0	Updated Total Petroleum Hydrocarbon (TPH) methodology; removed groundwater screening levels.
24	Section 7.0	Updated references
25	Table A-1	Updated NMED screening levels
26	Table A-2	Updated default exposure parameters
27	Table A-3	Table added displaying vapor intrusion screening levels
28	Tables B-1 and B-2	Updated chemical property information with references added
29	Table B-3	Table added showing input parameters and chemical properties for dermal tap-water pathway
30	Table C-1	Updated toxicity data
April 2015		
31	Section 2.7.7	Update preferred method for handling non-detects
January 2017		
1	Global	Updated toxicity data; includes changes to text, tables, equations, and soil screening levels in Appendix A
2	Section 1.3	New section addressing use of the guidance and screening levels
3	Section 2.1	Added information of application of a relative bioavailability correction factor in the calculation of soil ingestion screening levels for arsenic.
4	Section 2.1	Added equation for calculation of toxicity equivalents for dioxin/furan congeners
5	Section 2.1	Added discussion on essential nutrients
6	Section 2.1	Added discussion on perfluorinated compounds
7	Equation 27	Updated age-adjusted dermal exposure factor
8	Equation 36	Updated age-adjusted tap water dermal exposure factor, mutagens
9	Section 2.3.3	Clarification on use of lead screening levels
10	Section 2.5.1	Updated attenuation factors
11	Section 2.5.2	Added discussion on use of the Johnson and Ettinger (J&E) bulk soil model
12	Section 2.5.2.3	Clarified steps for analysis of the vapor intrusion pathway.
13	Section 2.6	Due to issues with the preliminary remediation goal calculator for the beef ingestion pathway, requirement for a quantitative assessment removed; only a qualitative analysis is required.
14	Section 2.7	Section re-written to address only site assessment and provide guidance on data quality objectives and background threshold values (BTVs).
15	Section 2.8	New section addressing site characterization, conceptual site models, and exposure intervals.
16	Section 2.8.3.1	New section on determining constituents of potential concern (COPCs) for organics and chemicals without background data.

17	Section 2.8.3.2	New section on comparison to BTVs using discrete data.
18	Section 2.8.3.3	New section on comparison to BTVs using incremental sample methodology (ISM) data.
19	Section 2.8.5.2	Added section for determination of UCLs for ISM data.
20	Section 4.9	Added allowance of additional lines of evidence for migration to groundwater.
21	Section 5.0	Clarification of how to assess risks/hazard to chemicals with both forms of toxicity.
22	Section 5.2	Added text and new equation to clarify how to assess risk from essential nutrients.
23	Section 6.1	New screening levels for TPH fractions
24	Appendix A, Table A-1	Screening levels for both carcinogenic and noncarcinogenic toxicity provided for all chemicals (previous versions only listed more conservative level). Added soil-to-groundwater migration screening levels based on New Mexico Water Quality Standards and/or Federal Maximum Contaminant Levels. Updated toxicity data; also added information of application of a relative bioavailability correction factor in the calculation of soil ingestion screening levels for arsenic.
25	Appendices A -C, New Chemicals	Screening levels have been added for the following chemicals: alachlor, atrazine, carbofuran, cobalt, dimethyl phthalate, glyphosate, 1-methylnaphthalene, 2-methylnaphthalene, nitrophenol, perfluorinated chemicals, perfluorohexane sulfonic acid, perfluorooctane sulfonate, perfluorooctanoic acid, simazine, and p-xylene.
February 2019		
1	Section 1.3	Clarified text for Step 1, determining COPCs.
2	Table 2-6	Added the soil-to-groundwater pathway
3	Section 2.8.3	Added clarification on handling duplicates.
4	Section 2.8.3.2	Updated to reflect organics and chemicals with background data. Includes new Sections 2.8.3.2.1 and 2.8.3.2.2 and additional clarifications on how to conduct site attribution analyses.
5	Section 2.8.4	Modified Section to address initial and refined exposure point concentrations
6	Section 4	Revised terminology for SSLs for the soil-to-groundwater pathway to reflect target leachate concentrations. Included addition of Equation 58 to address how to use target leachate concentrations compared to site data.
7	Section 5	Added clarification that overall risk and hazard calculations exclude the soil-to-groundwater pathway.
8	Table 5-1	Updated essential nutrient levels
9	Section 5.3	New section on PFAS, including preliminary screening levels for PFOA, PFOS, and PFHxS.

	Table 6-2	Added an SSL for gasoline
9	Table 6-4	Updated terminology to reflect target leachate concentrations. Updated groundwater SSLs and SL-SSLs and added values for gasoline
10	Appendix A, Table A-1	Revised table to only list target leachate concentration to be used in initial screening assessments.
11	Appendix A, Table A-3	Added table showing calculation of all target leachate concentrations.
12	Updated toxicity	RDX
13	Appendix E	Added supporting information on PFHxS
November 2021		
1	Section 2.8.2 and Table 2-6	Updated soil exposure level for ecological receptors (refer to Volume II of the SSG).
2	Section 2.5.2.1	Updated definition for an incomplete pathway for vapor intrusion.
3	Section 2.8.4.1	Added alternative method for EPCs for datasets with high numbers of non-detects.
4	Section 5.0	Added clarification that lead is to be evaluated individually and a HQ not added to the site HI.
5	Section 5.4	Added discussion of derivation of new screening levels for PFBS and PFNA. Removed text that PFAS risk should not be used to make regulator decisions or assess corrective action.
6	Section 6.0	Updated TPH SL-SSLs and added VISLs for TPH mixtures.
7	Table 5-3	Added screening levels for PFBS and PFNA.
8	Tables A-1, A-2, and A-3	Added new chemicals: 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, ammonium picrate, cyclohexane, 2-nitropropane, PFBS, PFNA, picric acid, and TMPA. Updated toxicity and SSLs for molybdenum, vinyl bromide, trans-1,2-dichloroethene, and 1,3-butadiene.
9	Appendix E	Updated drinking water data in Table 1 and added discussion on calculation of exposure.

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LIST OF ACRONYMS

AI	Adequate Intake
ALM	Adult Lead Methodology
ASTDR	Agency for Toxic Substances and Disease Registry
BGS	Below Ground Surface
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
BTV	Background Threshold Value
C	Celsius
CalEPA	California Environmental Protection Agency
CMTP	Composite Model for Leachate Migration with Transformation Products
COPC	Contaminants of Potential Concern
CSM	Conceptual Site Model
DAF	Dilution Attenuation Factor
DQO	Data Quality Objectives
EPA/ORD	Environmental Protection Agency Office of Research and Development
EPC	Exposure Point Concentration
EPH	Extractable Petroleum Hydrocarbons
EPI	Estimation Program Interface
GWQB	Groundwater Quality Bureau
HEAST	Health Effects Assessment Summary Tables
HWB	Hazardous Waste Bureau
IEUBK	Integrated Exposure Uptake Biokinetic
IRIS	Integrated Risk Information System
IUPAC	International Union of Pure and Applied Chemistry
IUR	Inhalation Unit Risk
J&E	Johnson and Ettinger
MADEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level
MDL	Minimum Detection Limit
MRL	Minimum Risk Level
MTBE	Methyl Tertiary Butyl Ether
NAPL	Non-aqueous Phase Liquid
NHL	Non-Hodgkin's Lymphoma
NJDEP	New Jersey Department of Environmental Protection
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NRCS	National Resource Conservation Service
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PEF	Particulate Emission Factor
PFAS	Polyfluoroalkyl and Perfluoroalkyl Compounds
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane Sulfonate
PPRTV	Provisional Peer-reviewed Toxicity Value
PRG	Preliminary Remediation Goal

LIST OF ACRONYMS, Cont.

RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RCRA	Resource Conservation and Recovery Act
RDA	Recommended Daily Allowance
RfC	Reference Concentration
RfD	Reference Dose
RSL	Regional Screening Level
SCEM	Site Conceptual Exposure Model
SL	Screening Level
SQL	Sample Quantitation Level
SSG	Soil Screening Guidance
SSL	Soil Screening Level
SVOC	Semi-volatile Organic Compound
TCDD	Tetrachlorodibenzo-p-dioxin
TCE	Trichloroethylene
TEF	Toxicity Equivalency Factor
TEQ	Toxicity Equivalent
TPH	Total Petroleum Hydrocarbon
TPHCWG	Total Petroleum Hydrocarbon Criteria Work Group
UCL	Upper Confidence Limit
UL	Upper Intake Limit
US EPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
UTL	Upper Tolerance Limit
VF	Volatilization Factor
VISL	Vapor Intrusion Screening Level
VOC	Volatile Organic Compound
VPH	Volatile Petroleum Hydrocarbons
WHO	World Health Organization
WQCC	Water Quality Control Commission

1.0 INTRODUCTION

The New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) and the Ground Water Quality Bureau (GWQB) have developed this soil screening guidance (SSG) for internal department use within corrective action programs. The SSG discusses the methodology used to derive chemical-specific soil screening levels (SSLs), tap water screening levels, and vapor intrusion screening levels (VISLs). In addition, guidance is provided to assist in identifying and evaluating appropriate exposure pathways and receptors. Finally, this document provides generic SSLs, tap water SLs, and VISLs for chemicals commonly found at contaminated sites based on default exposure parameters under residential and non-residential land-use scenarios.

The SSG provides site managers with a framework for developing and applying the SSLs and is likely to be most useful for determining whether areas or entire sites are contaminated to an extent that warrants further investigation. It is intended to assist and streamline the site investigation and corrective action process by focusing resources on those sites or areas that pose the greatest risk to human health and the environment. Implementation of the methodologies outlined within this SSG may significantly reduce the time necessary to complete site investigations and cleanup actions at certain sites, as well as improve the consistency of these investigations.

Between various sites there can exist a wide spectrum of contaminant types and concentrations. The level of concern associated with those concentrations depends on several factors, including the likelihood of exposure to concentrations that could impact human health or ecological receptors. At one end of the spectrum are levels that clearly warrant a response action; at the other end are levels that are below regulatory concern. Appropriate cleanup goals for a site may fall anywhere within this range depending on site-specific conditions. Screening levels such as SSLs identify the lower end of this spectrum – levels below which there is generally no need for further concern—provided the conditions associated with the development of the SSLs are consistent with the site being evaluated. It is important to note that SSLs do not in themselves represent cleanup standards, and the SSLs alone do not trigger the need for a response action or define "unacceptable" levels of contamination in soil.

1.1 Organization of the Document

The NMED SSG is organized into five major sections with supporting appendices. The remainder of Section 1 addresses the purpose of the NMED SSLs and outlines the scope of the document. Section 2 outlines the receptors, exposure pathways, and exposure assumptions used in calculating the NMED SSLs. It also discusses the risk levels on which the SSLs are predicated and presents the SSL model assumptions. Finally, Section 2 discusses site assessment/characterization activities that should be completed prior to comparing site contaminant concentrations with SSLs. These activities include development of data quality objectives, conducting site sampling, preparation of a preliminary conceptual site model (CSM), and identification of contaminants of potential concern (COPCs). Section 3 provides a detailed description of the process used to develop pathway-specific SSLs. Included in this section is a discussion of the human health basis for the SSLs, additive risk, and acute exposures. Additional

topics discussed in Section 3 include chemical specific parameters used to develop the SSLs and calculation of volatilization factors, particulate emission factors and soil saturation limits. Section 4 presents methodologies for assessing the potential for migration of contaminants to groundwater from contaminated soil in concert with generic and site-specific leaching models. Section 5 addresses special use considerations for addressing contaminant concentrations in soil and notes specific problems that can arise when applying the SSLs to specific sites. Finally, Section 6 addresses the screening criteria that should be applied at sites with potential petroleum releases. Soil and tap water screening levels for contaminants are presented in Table A-1 of Appendix A. Table A-2 of Appendix A presents the default exposure factor values used in the generation of the NMED SSLs. Table A-3 presents all derived target soil leachate concentrations. Screening levels for the vapor intrusion pathway are presented in Table A-4 of Appendix A. Physical-chemical values used in the calculation of the SSLs are presented in Tables B-1, B-2, and B-3 of Appendix B. Toxicity criteria are presented in Table C-1 of Appendix C. Additional discussion of polychlorinated biphenyls (PCBs) is provided in Appendix D. Appendix E provides recommendations for evaluating potential risk and hazard from perfluoroalkyl compounds.

1.2 Scope of the Soil Screening Guidance

The SSG incorporates readily obtainable site data and utilizes methods from various United States Environmental Protection Agency (US EPA) risk assessment guidance and derives site-specific screening levels for selected contaminants and exposure pathways. Key attributes of the SSG include default values for generic SSLs where site-specific information is unavailable, and the identification of parameters for which site-specific information is needed for the development of site-specific SSLs. The goal of the SSG is to provide a consistent approach for developing site-specific SSLs for evaluating facilities under the auspices of the corrective action process within NMED.

The NMED SSLs are based on a 1E-05 target risk for carcinogens, or a hazard quotient of 1.0 for noncarcinogens. In instances where an individual contaminant has the capacity to elicit both types of responses, both SSLs are provided. SSLs for migration to groundwater are based on NMED-specific tap water SSLs. As such, the NMED SSLs serve as a generic benchmark for screening level comparisons of contaminant concentrations in soil. NMED anticipates that the SSLs will be used as a tool to facilitate prompt identification of those contaminants and areas that represent the greatest risks to human health and the environment. While concentrations above the NMED SSLs presented in this document do not automatically designate a site as "contaminated" or trigger the need for a response action, detected concentrations in site soils exceeding screening levels suggest that further evaluation is appropriate. Further evaluation may include additional sampling to better characterize the nature and extent of contamination, consideration of background levels, reevaluation of COPCs or associated risk and hazard using site-specific parameters, and/or a reassessment of the assumptions associated with the generic SSLs (e.g., appropriateness of route-to-route extrapolations, use of chronic toxicity values to evaluate childhood and construction-worker exposures).

Prior to calculating site-specific SSLs, each relevant chemical specific parameter value and toxicological datum should be checked against the most recent version of its source to

determine if updated data are available.

If a NMED SSL is not listed for a given chemical, other sources of screening levels should be consulted, such as the US EPA Regional Screening Levels (RSLs) (US EPA, 2018a or most current), or a review of toxicological data should be conducted and if available, a screening level calculated for that given chemical. Care should be used when other sources of screening levels are used to ensure that target risk/levels used in development of the levels are consistent with those applied by NMED. For example, the US EPA carcinogenic RSLs are based on a 1E-06 risk level and must be adjusted to a 1E-05 risk level for use. RSLs for noncarcinogens are provided for hazards of 1.0 and 0.1; the RSLs based on a hazard quotient of 1.0 should be applied.

1.2.1 Exposure Pathways

A complete exposure pathway consists of (1) a source, (2) a mechanism of contaminant release, (3) a receiving or contact medium, (4) a potential receptor population, and (5) an exposure route. All five elements must be present for the exposure pathway to be considered complete. SSLs have been developed for use in evaluating several exposure scenarios representing a variety of potential land uses: residential, commercial/industrial, and construction. The SSG presents lists of potential pathways for each scenario, though these lists are not intended to be exhaustive. Instead, each list represents a set of typical exposure pathways likely to account for the majority of exposure to contaminants in soil or other media at a given site. These include:

- Direct (and incidental) ingestion of soil,
- Dermal contact with soil,
- Inhalation of volatiles and fugitive dusts from contaminated soil,
- Migration of chemicals through soil to an underlying potable aquifer or water-bearing unit,
- Ingestion of tap water during domestic use,
- Dermal contact with tap water during domestic use,
- Inhalation of volatile organic compounds (VOCs) volatilized from tap water into indoor air during domestic use,
- Inhalation of volatiles in indoor air via the subsurface vapor intrusion pathway, and
- Ingestion of potentially contaminated beef.

Under some site-specific situations, additional complete exposure pathways may be identified. In these cases, a site-specific evaluation of risk is warranted under which additional exposure pathways can be considered. If other land uses and exposure scenarios are determined to be more appropriate for a site (e.g., home gardening, recreational land use, hunting, and/or Native American land use), the exposure pathways addressed in this document should be modified or augmented accordingly or a site-specific risk assessment should be conducted. Early identification of the need for additional information is important because it facilitates development of a defensible sampling and analysis strategy.

The exposure pathways addressed in this guidance are presented by land-use scenario in Table 1-1.

Table 1-1. Exposure Pathways Evaluated in Soil Screening Guidance

Potential Exposure Pathway	Residential	Commercial /Industrial	Construction
Direct ingestion of soil	✓	✓	✓
Dermal contact with soil	✓	✓	✓
Inhalation of dust and volatiles from soil	✓	✓	✓
Inhalation of VOCs from vapor intrusion	✓	✓	--
Ingestion of tap water	✓	--	--
Dermal contact with tap water	✓	--	--
Inhalation of VOCs volatilized from tap water during domestic use	✓	--	--
Ingestion of beef	✓	--	--

1.2.2 Exposure Assumptions

SSLs represent risk-based concentrations in soil derived from equations combining exposure assumptions with toxicity criteria following the US EPA's preferred tiered hierarchy of toxicological data. The models and assumptions used were developed to be consistent with the Superfund concept of "reasonable maximum exposure" (US EPA 1989 and 2009). This is intended to provide an upper-bound estimate of chronic exposure by combining both average and conservative (i.e., 90^{th} to 95^{th} percentile) values in the calculations. The default intake and duration assumptions presented here are intended to be protective of all potentially exposed populations for each land use consideration. Exposure point concentrations in soil should reflect either directly measured or estimated values using fate and transport models. When assessing chronic, long-term exposures, the maximum detected site concentration should be used for an initial screen against the SSLs. A more refined assessment may include use of an estimate of the average [95 percent upper confidence level (UCL) of the mean] concentration if sufficient site data are available to allow for an accurate estimation of the UCL. Where the potential for acute toxicity may be of concern, estimates based on the maximum exposure may be more appropriate.

The resulting estimate of exposure is then compared with chemical-specific toxicity criteria. To calculate the SSLs, the exposure equations and pathway models are rearranged to back calculate an "acceptable level" of a contaminant in soil corresponding to a specific level of target risk or hazard.

1.2.3 Target Risk and Hazard

Target risk and hazard levels for human health are risk management-based criteria for carcinogenic and noncarcinogenic responses, respectively, to determine: (1) whether site-related contamination poses an unacceptable risk to human health and requires corrective action or (2) whether implemented corrective action(s) sufficiently protects human health. If an estimated risk or hazard falls within the target range, the risk manager must decide whether or not the site

poses an unacceptable risk. This decision should consider the degree of inherent conservatism or level of uncertainty associated with the site-specific estimates of risk and hazard. An estimated risk that exceeds these targets, however, does not necessarily indicate that current conditions are not safe or that they present an unacceptable risk. Rather, a site risk calculation that exceeds a target value may simply indicate the need for further evaluation or refinement of the exposure model.

For cumulative exposure via the ingestion, inhalation, and dermal pathways, toxicity criteria are used to calculate an acceptable level of contamination in soil. SSLs are based on a carcinogenic risk level of one-in-one-hundred thousand (1E-05) and a noncarcinogenic hazard quotient of 1.0. A carcinogenic risk level is defined as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. The noncarcinogenic hazard quotient assumes that there is a level of exposure below which it is unlikely for even sensitive populations to experience adverse health effects.

1.2.4 SSL Model Assumptions

The models used to calculate inhalation exposure and protection of groundwater based on potential migration of contaminants in soil are intended to be utilized at an early stage in the site investigation process when information regarding the site may be limited. For this reason, the models incorporate a number of simplifying assumptions. For instance, the models assume an infinite contaminant source, i.e., a constant concentration is maintained for the duration of the exposure period. Although this is a highly conservative assumption, finite source models require accurate data regarding source size and volume. Such data are unlikely to be available from limited sampling efforts. The models also assume that contamination is homogeneous throughout the source and that no biological or chemical degradation occurs. Where sufficient site-specific data are available, more detailed finite-source models may be used in place of the default model assumptions presented in this SSG.

1.3 How to Use the Guidance in Volume I

The intent of this guidance is to streamline the risk assessment process using a step-wise approach. The human health screening level risk assessment should be performed after nature and extent of contamination has been fully defined. The general steps for conducting the human health screening risk assessment are:

Step 1: Determine constituents of potential concern (COPCs). This includes conducting a site attribution analysis and elimination of some constituents through comparison of site concentrations to background levels.

Step 2: Compare maximum detected site concentrations for COPCs to appropriate SSLs for each potential current or future receptor. Note that a review of Table A-1 is required, as a chemical may present both carcinogenic and noncarcinogenic heath toxicity. Comparison to both screening levels, if available, is required.

- If the resulting Hazard Index (HI) (sum of all hazard quotients, HQs) is less than 1.0, stop; no additional assessment for noncarcinogens is needed. Move to Step 5.
- If resulting cancer risk (sum of all cancer risks) is less than 1E-05, stop; no additional assessment for carcinogens is required. Move to Step 5.

Note: risks/hazards across all appropriate pathways must be included in the comparison to NMED target levels of 1 and 1E-05. Any risk/hazard from vapor intrusion or other site-specific pathway must be added to the summed risk/hazard calculated using the SSLs. The beef ingestion pathway should be addressed in the Uncertainty Section.

Step 3: If Step 2 results in adverse risk/hazard, calculate refined exposure point concentrations (EPCs).

Step 4: Compare EPCs to the appropriate SSLs for each receptor:

- If the resulting Hazard Index (HI) is less than 1.0, stop; no additional assessment for noncarcinogens is needed. Move to Step 5.
- If resulting cancer risk is less than 1E-05, stop; no additional assessment for carcinogens is required. Move to Step 5.

Step 5: Compare the site concentrations to the soil-to-groundwater target soil leachate concentrations (based on a dilution attenuation factor of 20). Maximum detected concentrations should be applied first, followed by use of a refined EPC and/or site-specific data, if the initial comparison results in an exceedance of the applicable soil-to-groundwater target soil leachate concentrations.

Step 6: Discuss Uncertainties

Step 7: If Step 4 and/or Step 5 results in excess risk/hazard or potential to impact groundwater, conduct additional site-specific refinements of the assessment and/or implement corrective actions.

Volume II contains guidance for conducting the ecological screening assessment.

2.0 DEVELOPMENT OF PATHWAY SPECIFIC SOIL SCREENING LEVELS

The following sections present the technical basis and limitations used to calculate SSLs, tap water screening levels (SLs), and VISLs for residential, commercial/industrial, and construction land use scenarios. The equations used to evaluate inhalation and migration to groundwater include a number of easily obtainable site-specific input parameters. Where site-specific data are not available, conservative default values are presented. The equations used are presented in Sections 2.2 through 2.6. Generic SSLs and tap water screening levels are calculated using these default values and are presented in Table A-1 of Appendix A. Vapor intrusion screening levels were calculated for chemicals considered toxic and volatile and are presented in Table A-4.

2.1 Human Health Basis

The toxicity criteria used for calculating the SSLs are presented in Table C-1 of Appendix C. The selected toxicity values were based on chronic exposure. The primary sources for the human health benchmarks follow the US EPA Superfund programs tiered hierarchy of human health toxicity values (US EPA 2003). Although the US EPA 2003 identified several Tier 3 sources, a hierarchy among the Tier 3 sources was not assigned by the US EPA. For the calculation of NMED SSLs, the following hierarchy of sources was applied in the order listed, and is similar to the hierarchy utilized in the calculation of US EPA's RSLs (US EPA, 2016a):

1) Integrated Risk Information System (IRIS) (US EPA, 2018b) (www.epa.gov/iris),

2) Provisional peer reviewed toxicity values (PPRTVs) (http://hhpprtv.ornl.gov/) and appendices,

3) Agency for Toxic Substances and Disease Registry (ATSDR) (http://www.atsdr.cdc.gov/) and minimal risk levels (MRLs) (http://www.atsdr.cdc.gov/mrls/index.asp),

4) California EPA's Office of Environmental and Health Hazard Assessment values (CalEPA) (http://www.oehha.ca.gov/air/allrels.html and http://www.oehha.ca.gov/risk/pdf/tcdb072109alpha.pdf), and

5) Health Effects Assessment Summary Tables (HEAST) (US EPA 1997a).

Special assumptions were also applied in determining appropriate toxicological data for certain chemicals.

Dioxins/Furans. Toxicity data for the dioxin and furan congeners were assessed using the 2005 World Health Organization's (WHO) toxicity equivalency factors (TEF) (Van den berg, et al 2006) and are summarized in Table 2-1. When screening risk assessments are performed for dioxins/furans at a site, the TEFs in Table 2-1 should be applied to the analytical results and summed for each sample location; the sum, or toxicity equivalent (TEQ) as calculated using Equation 1, should be compared to the NMED SSL for 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD).

Equation 1
Calculation of Toxicity Equivalents for Dioxin and Furan Congeners

$$TEF_i \times C_i = TEC_i$$

$$\sum TEC_i = TEQ$$

TEFi	Congener-specific toxicity equivalency factor (Table 2-1)
Ci	Congener-specific concentration
TEQ	Toxicity Equivalent

Table 2-1. Dioxin and Furan Toxicity Equivalency Factors

Dioxin and Furan Congeners	TEF
Chlorinated dibenzo-p-dioxins	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
Chlorinated dibenzofurans	
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.0003

Polychlorinated biphenyls (PCBs). Toxicity data for Aroclors were taken from the IRIS database. Aroclor 1016 is considered low risk; therefore, toxicity values deemed as "lowest risk" were applied. It was assumed that all the other Aroclors are high risk; as such, toxicity values deemed as "highest risk" were applied.

Toxicity data for the dioxin-like PCBs were calculated relative to 2,3,7,8-TCDD toxicity. TEFs for non-ortho [International Union of Pure and Applied Chemistry (IUPAC) numbers 77, 81, 126, and 169)] and mono-ortho congeners (IUPAC numbers 105, 114, 118, 123, 156, 157, 167, and 189) were assessed using the 2005 WHO TEFs (Van den Berg, et al 2006) while TEFs for di-ortho congeners (IUPAC numbers 170 and 180) are

taken from Ahlborg, et al, 1993 (see Table 2-2).

Table 2-2. PCB TEFs

IUPAC No.	Structure	TEF
77	3,3',4,4'-TetraCB	0.0001
81	3,4,4',5-TetraCB	0.0003
105	2,3,3',4,4'-PeCB	0.00003
114	2,3,4,4',5-PeCB	0.00003
118	2,3',4,4',5-PeCB	0.00003
123	2',3,4,4',5-PeCB	0.00003
126	3,3',4,4',5-PeCB	0.1
156	2,3,3',4,4',5-HxCB	0.00003
157	2,3,3',4,4',5'-HxCB	0.00003
167	2,3',4,4',5,5'-HxCB	0.00003
169	3,3',4,4',5,5'-HxCB	0.03
189	2,3,3',4,4',5,5'-HpCB	0.00003
170	2,2',3,3',4,4',5-HpCB	0.0001
180	2,2',3,4,4',5,5'-HpCB	0.00001

Arsenic. The SFo and RfDo for arsenic were multiplied by a relative bioavailability correction factor of 0.6 in the calculation of the SSLs for ingestion of soil. Relative bioavailability accounts for differences in the bioavailability of a contaminant between the medium of exposure (soil) and the media associated with the toxicity value. The factor is applied in the derivation of soil ingestion screening levels because the arsenic RfD and CSF are derived from drinking water studies (US EPA, 2016a).

Cadmium. IRIS provides an oral reference dose (RfD) for both water and food. For deriving the tap water SSL, the RfD for water was applied and for the soil-based SSL, the RfD for food was applied.

Vanadium. The oral reference dose (RfD) for vanadium was calculated based on the RfDo for vanadium pentoxide and factoring out the molecular weight of the oxide ion.

Lead. An SSL was not calculated for lead using the equations within this guidance. Rather, the US EPA recommended levels for lead, based on blood-lead modeling were applied for the residential scenarios (Integrated Exposure Uptake Biokinetic Model, IEUBK) and industrial/construction workers (Adult Lead Methodology).

Total Chromium. Toxicity data for total chromium were adjusted based on a ratio of 1:6 (hexavalent chromium to trivalent chromium). If there is reason to believe that this ratio for total chromium is not representative of site conditions, then valence-specific site concentrations and SSLs for trivalent chromium (chromium (III)) and hexavalent chromium (chromium (VI)) should be applied. See Section 5.1 for further information on the use of chromium screening levels.

Chromium (VI). The oral cancer slope factor selected for chromium (VI) is based on a publication by the New Jersey Department of Environmental Protection (NJDEP) entitled *Derivation of Ingestion-Based Soil Remediation Criterion for Cr^{+6} Based on the NTP Chronic Bioassay Data for Sodium Dichromate Dihydrate* (April 8, 2009). This publication presents cancer potency values derived from a two-year dose-response study conducted by the National Toxicology Program (2008). NJDEP derived an oral cancer potency value of 0.5 mg/kg-day for chromium (VI). See Section 5.1 for further information on the use of chromium screening levels.

The inhalation unit risk (IUR) factor for chromium (VI) was derived by multiplying the total chromium IUR by seven (7) to account for a chrome speciation ratio of 1:6 (chromium (VI) to chromium (III)). See Section 5.1 for further information on the use of chromium screening levels.

Xylenes. Toxicity criteria for xylenes (mixture) from US EPA's IRIS were used as surrogate values for the three isomers of xylenes (o-xylene, m-xylene, and p-xylene) based on structural similarity.

Essential Nutrients. Toxicity for the essential nutrients (calcium, chloride, magnesium, phosphorus, potassium, and sodium) was based on dietary guidelines. See Section 5.2 for further information on how the essential nutrient screening levels were developed and how to use these levels.

Phenanthrene. Based on structural similarity, toxicity data for pyrene were used as surrogate values for phenanthrene.

Polycyclic aromatic hydrocarbons (PAHs). Toxicity data for PAHs were calculated by applying TEFs relative to benzo(a)pyrene. The selected TEFs presented in US EPA (1993) were applied in the calculation of NMED SSLs and are listed in Table 2-3.

Table 2-3. Polycyclic Aromatic Hydrocarbon Toxicity Equivalency Factors

Polycyclic Aromatic Hydrocarbon	TEF
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenz(a,h)anthracene	1.0
Indeno(1,2,3-cd)pyrene	0.1

Perfluorinated Compounds. Perfluorinated compounds are considered an emerging contaminant. These include perfluorohexane sulfonic acid (PFHxS), perfluorooctane sulfonate (PFOS), and perfluorooctanoic acid (PFOA). Additional discussion of perfluorinated compounds and recommendations on assessing them in risk assessments is provided in Section 5.3.

2.1.1 Additive Risk

It is important to note that no consideration is provided in the calculation of individual NMED SSLs for additive risk when exposures to multiple chemicals occur. The SSG addresses this issue in Section 5. Because the NMED SSLs for carcinogenic effects correspond to a 1E-05 risk level individually, exposure to multiple contaminants may result in a cumulative site risk that is above the anticipated risk management range. While carcinogenic risks of multiple chemicals are simply added together, the issue of additive hazard is more complex for noncarcinogens because of the theory that a threshold exists for noncarcinogenic effects. This threshold is defined as the level below which adverse effects are not expected to occur and represents the basis for the RfD and reference concentration (RfC). Since adverse effects are not expected to occur at the RfD or RfC and the SSLs are derived by setting the potential exposure dose to the RfD or RfC, the SSLs do not address the risk of exposure to multiple chemicals at levels where the individual chemicals alone would not be expected to cause any adverse effects. In such cases, the SSLs may not provide an accurate indicator for the likelihood of harmful effects. As a first-tier screening approach, noncarcinogenic effects should be considered additive. If the hazard index results in a value above the target level of 1.0, noncarcinogenic effects may be evaluated for those chemicals with the same toxic endpoint and/or mechanism of action. The sources provided in Section 2.1 should be consulted to determine the endpoint and/or target organ system prior to attempting to evaluate the additive health effects resulting from simultaneous exposure to multiple noncarcinogenic contaminants.

2.1.2 Acute Exposures

The exposure assumptions used to develop the SSLs are based on a chronic exposure scenario and do not account for situations where high-level exposures may result in acute toxic effects. Such situations may arise when contaminant concentrations are very high or may result from specific site-related conditions and/or behavioral patterns (e.g., pica behavior in children). Such exposures may be of concern for those contaminants that primarily exhibit acute health effects. For example, toxicological information regarding cyanide and phenol indicate that acute effects may be of concern for children exhibiting pica behavior. Pica is typically described as a compulsive craving to ingest non-food items (such as clay or paint). Although it can be exhibited by adults as well, it is typically of greatest concern in children because they often exhibit behavior (e.g., outdoor play activities and greater hand-to-mouth contact) that results in greater exposure to soil than for a typical adult. In addition, children also have a lower overall body weight relative to the predicted intake.

2.1.3 Early-Life Exposures to Carcinogens

US EPA's (2005a) Supplemental Guidance states that early life exposures (i.e., neonatal and early life) to certain carcinogens can result in an increase in cancer risk later in life. US EPA's (2005a) suggests that age-specific factors be applied to the estimated cancer risks. These factors should address four life stages: 1) children under 2 years of age; 2) children aged 2 to 6 years; 3) children 6 years to 16 years of age; and 4) children over 16 years of age. Effects of mutagenicity have been incorporated into the SSLs for those contaminants which are considered carcinogenic

by a mutagenic mode of action.

2.1.4 Direct Ingestion

Exposure to contaminants through incidental ingestion of soil can result from the inadvertent consumption of soils adhering to the hands, food items, or objects that are placed into the mouth. It can also result from swallowing dust particles that have been inhaled and deposited in the mouth. Commercial/industrial, construction workers, and residential receptors may inadvertently ingest soil that adheres to their hands while involved in work- or recreation-related activities. Calculation of SSLs for direct ingestion are based on the methodology presented in US EPA's *Risk Assessment Guidance for Superfund (RAGS): Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim* (US EPA 1991), *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), and *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a).

2.1.5 Dermal Absorption

Exposure to soil contaminants may result from dermal contact with contaminated soil and the subsequent absorption of contaminants through the skin. Contact with soil is most likely to occur as a result of digging, gardening, landscaping, or outdoor recreation activities. Excavation activities may also be a potential source of exposure to contaminants, particularly for construction workers. Calculation of the SSLs for dermal contact with soil under the residential exposure scenario is based on the methodology presented in US EPA's *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim* (1991), and *Soil Screening Guidance: Technical Background Document* (US EPA 1996a). The suggested default input values used to develop the NMED SSLs are consistent with US EPA's interim *RAGS, Part E, Supplemental Guidance for Dermal Risk Assessment* (US EPA 2004a).

2.1.6 Inhalation

US EPA toxicity data indicate that risks from exposure to some chemicals via the inhalation pathway far outweigh the risk via ingestion or dermal contact; therefore, the NMED SSLs have been designed to address inhalation of volatiles and fugitive dusts. To address the soil/sediment-to-air pathways, the SSL calculations incorporate a volatilization factor (VF) for volatile contaminants (See Section 3.1) and a particulate emission factor (PEF) (See Section 3.3) for semi-volatile and inorganic contaminants. The SSLs follow the procedures for evaluating inhalation soil, VOCs, and fugitive dust particles presented in US EPA's *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), Final (US EPA 2009), Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim* (US EPA 1991), *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (US EPA 2005a), and *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a).

VOCs may adhere to soil particles or be present in interstitial air spaces in soil and may volatilize into ambient air. This pathway may be particularly significant if the VOC emissions are concentrated in indoor spaces of onsite buildings, or buildings that may be built in the future. If volatiles are present in subsurface media (e.g., soil-gas or groundwater), volatilization through the vadose zone and into indoor air could occur. NMED VISLs were calculated to address this type of exposure using the methods outlined in Section 2.5. VOCs are considered those chemicals having a Henry's Law constant greater than 1E-05 atmospheres – cubic meter per mole (atm-m^3/mole) and a molecular weight less than 200 grams per mole (g/mole).

Inhalation of contaminants via inhalation of fugitive dusts is assessed using a PEF that relates the contaminant concentration in soil/sediment with the concentration of respirable particles in the air due to fugitive dust emissions. It is important to note that the PEF used to address residential and commercial/industrial exposures evaluates only windborne dust emissions and does not consider emissions from traffic or other forms of mechanical disturbance which could lead to a greater level of exposure. The PEF used to address construction worker exposures evaluates windborne dust emissions and emissions from vehicle traffic associated with construction activities. Therefore, the fugitive dust pathway should be considered carefully when developing the CSM at sites where receptors may be exposed to fugitive dusts by other mechanisms. The development of the PEF for both residential and non-residential land uses is discussed further in Section 3.3.

2.1.7 Contaminants of Emerging Concern

Contaminants of emerging concern are those contaminants possibly present in environmental media that are suspected to elicit adverse effects to human and ecological receptors, but do not have established health standards or established analytical methods. As many agencies, including the US EPA, are working to understand the types of effects and levels of concern in environmental media, it is important to consider whether emerging contaminants may be present at facilities in New Mexico.

For facilities where contaminants of emerging concern are detected in site media, and SSLs are not available, a qualitative discussion of potential exposure and impact on overall risk/hazard must be included in the risk assessment.

2.2 Soil Screening Levels for Residential Land Uses

Residential exposures are assessed based on child and adult receptors. As discussed below, the child forms the basis for evaluation of noncarcinogenic effects incurred under residential exposures, while carcinogenic responses are modeled based upon age-adjusted values to account for exposures averaged over a lifetime. Under most circumstances, onsite residential receptors are expected to be the most conservative receptor basis for risk assessment purposes due to the assumption that exposure occurs 24 hours (hr) a day, 350 days per year (yr), extending over a 26-year exposure duration. Table 2-4 provides a summary of the exposure characteristics and parameters associated with a residential land use receptor (US EPA, 2014a and 2017).

Table 2-4. Summary of the Residential Land Use Receptors

Exposure Characteristics	• Substantial soil exposure (esp. children) • High soil ingestion rate (esp. children) • Significant time spent indoors • Long-term exposure • Surface and subsurface soil exposure [0-10 feet below ground surface (bgs)]
Default Exposure Parameters	
Exposure frequency (days/yr)	350
Exposure duration (yr)	6 (child) 20 (adult)
Soil ingestion rate (mg/day)	200 (child) 100 (adult)
Body Weight (kg)	15 (child) 80 (adult)
Skin surface area exposed (cm^2)	2,690 (child) 6,032(adult)
Skin-soil adherence factor (mg/cm^2)	0.2 (child) 0.07 (adult)
cm^2 – square centimeters kg - kilograms mg – milligrams	

2.2.1 Residential Receptors

A residential receptor is assumed to be a long-term receptor occupying a dwelling within the site boundaries, and thus, is exposed to contaminants 24 hours per day, and is assumed to live at the site for 26 years [representing the 90^{th} percentile of the length of time someone lives in a single location (US EPA, 2014a)], remaining onsite for 350 days per year. Exposure to soil (to depths of zero to 10 feet bgs) is expected to occur during home maintenance activities, yard work and landscaping, and outdoor play activities. The SSLs do not take into consideration ingestion of homegrown produce/meat/dairy or inhalation of volatiles migrating indoors via vapor intrusion. If these pathways are complete, analysis of risks resulting from these additional exposure pathways must be determined (refer to Sections 2.5 and 2.6) and added to the risks determined using the SSL screen (Equations 55, 56, and 57).

Contaminant intake is assumed to occur via three exposure pathways – direct ingestion, dermal absorption, and inhalation of volatiles and fugitive dusts. For the residential scenario, both adult and child receptors were evaluated because children often exhibit behavior (e.g., greater hand-to-mouth contact) that can result in greater exposure to soils than those associated with a typical adult. In addition, children also have a lower overall body weight relative to the predicted intake.

Equations 2 and 3 are used to calculate cumulative SSLs for a residential receptor exposed to noncarcinogenic and carcinogenic contaminants via all three exposure pathways (ingestion of soil, inhalation of soil, and dermal contact with soil). Default exposure parameters are provided for use when site-specific data are not available.

Noncarcinogenic contaminants are evaluated based solely on childhood exposures using Equation 2. By combining the higher contaminant intake rates with the lower relative body weight, "childhood only" exposures lead to a lower, or more conservative, risk-based concentration compared to an adult-only exposure. In addition, this approach is considered conservative because it combines the higher 6-year exposure for children with chronic toxicity criteria.

Unlike noncarcinogens, the duration of exposure to carcinogens is averaged over the lifetime of the receptor because of the assumption that cancer may develop even after actual exposure has ceased. As a result, the total dose received is averaged over a lifetime of 70 years. In addition, to be protective of exposures in a residential setting, the carcinogenic exposure parameter values are age-adjusted to account for exposures incurred in children (1-6 years of age) and adults (26 years, 90th percentile for current resident time, US EPA, 2014a). Carcinogenic exposures are age-adjusted to account for the physiological differences between children and adults as well as behavioral differences that result in markedly different relative rates of exposure. Equations 4 and 5 are used to calculate age-adjusted ingestion, dermal and inhalation factors which account for the differences in soil ingestion rate, skin surface area, soil adherence factors, inhalation rate, and body weight for children versus adults. The age-adjusted factors calculated using these equations are applied in Equation 3 to develop generic NMED SSLs for carcinogenic effects.

Equation 2
Combined Exposures to Noncarcinogenic Contaminants in Soil, Residential Scenario

$$C_{oral} = \frac{THQ \times AT_r \times BW_c}{EF_r \times ED_c \times (1/RfD_o) \times IRS_c \times (10^{-6})}$$

$$C_{inh} = \frac{THQ \times AT_r}{EF_r \times ED_c \times ET_{rs} \times (1/RfC) \times [(1/VF_s) + (1/PEF_w)]}$$

$$C_{dermal} = \frac{THQ \times AT_r \times BW_c}{EF_r \times ED_c \times [1/(RfD_o \times GIABS)] \times SA_c \times AF_c \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{res} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{inh}} + \frac{1}{C_{dermal}}}$$

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
C_{dermal}	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
C_{inh}	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{res}	Soil screening level, all pathways (mg/kg)	Chemical-specific
THQ	Target hazard quotient	1
BW_c	Body weight, child (kg)	15
AT_r	Averaging time, noncarcinogens (days)	ED_c x 365
EF_r	Exposure frequency, resident (day/yr)	350
ED_c	Exposure duration, child (yr)	6
ET_{rs}	Exposure time, resident (hr/day x day/hr)	1
IRS_c	Soil ingestion rate, child (mg/day)	200
RfD_o	Oral reference dose (mg/kg-day)	Chemical-specific
SA_c	Dermal surface area, child (cm^2/day)	2,690
AF_c	Soil adherence factor, child (mg/cm^2)	0.2
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
ABS_d	Skin absorption factor (unitless)	Chemical-specific
RfC	Inhalation reference concentration (mg/m^3)	Chemical-specific
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 46
PEF_w	Particulate emission factor (m^3/kg)	See Equation 49

Equation 3
Combined Exposures to Carcinogenic Contaminants in Soil, Residential Scenario

$$C_{oral} = \frac{TR \times AT_r}{CSF_o \times IFS_{adj} \times 10^{-6}}$$

$$C_{inh} = \frac{TR \times AT_r}{IUR \times 1000 \times EF_r \times \left(\frac{1}{VF_s} + \frac{1}{PEF_w}\right) \times ED_r \times ET_{rs}}$$

$$C_{dermal} = \frac{TR \times AT_r}{DFS_{adj} \times \frac{CSF_o}{GIABS} \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{res} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{inh}} + \frac{1}{C_{dermal}}}$$

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
C_{dermal}	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
C_{inh}	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{res}	Soil screening level, all pathways (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
IFS_{adj}	Age-adjusted soil ingestion factor (mg/kg)	See Equation 4
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
DFS_{adj}	Age-adjusted dermal factor (mg/kg)	See Equation 5
ABS_d	Skin absorption factor (unitless)	Chemical-specific
1000	Unit conversion factor (µg/mg)	1000
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific
ED_r	Exposure duration, resident (yr)	26
ET_{rs}	Exposure time, resident (hr/day x day/hr)	1
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 46
PEF	Particulate emission factor (m^3/kg)	See Equation 47

Equation 4
Calculation of Age-Adjusted Soil Ingestion Factor

$$IFS_{adj} = \frac{EF \times ED_c \times IRS_c}{BW_c} + \frac{EF \times (ED_r - ED_c) \times IRS_a}{BW_a}$$

Parameter	Definition (units)	Default
IFS_{adj}	Age-adjusted soil ingestion factor for carcinogens (mg/kg)	36,750
EF	Exposure frequency (day/yr)	350
ED_c	Exposure duration, child (yr)	6
IRS_c	Soil ingestion rate, child (mg/day)	200
BW_c	Body weight, child (kg)	15
ED_r	Exposure duration, resident (yr)	26
IRS_a	Soil ingestion rate, adult (mg/day)	100
BW_a	Body weight, adult (kg)	80

Equation 5
Calculation of Age-Adjusted Soil Dermal Factor

$$DFS_{adj} = \frac{EF \times ED_c \times SA_c \times AF_c}{BW_c} + \frac{EF \times (ED_r - ED_c) \times SA_a \times AF_a}{BW_a}$$

Parameter	Definition (units)	Default
DFS_{adj}	Age-adjusted dermal factor for carcinogens (mg /kg)	112,266
EF	Exposure frequency (day/yr)	350
ED_c	Exposure duration, child (yr)	6
AF_c	Soil adherence factor, child (mg/cm^2)	0.2
SA_c	Dermal surface area, child (cm^2/day)	2,690
BW_c	Body weight, child (kg)	15
ED_r	Exposure duration, resident (yr)	26
AF_a	Soil adherence factor, adult (mg/cm^2)	0.07
SA_a	Dermal surface area, adult (cm^2/day)	6,032
BW_a	Body weight, adult (kg)	80

Equations 2 and 3 are appropriate for all chemcials with the exception of vinyl chloride, trichloroethylene, and those carcinogens exhibiting mutegenic toxicity. For vinyl chloride, the US EPA IRIS database provides cancer slope factors for both a child and an adult. The child-based cancer slope factor takes into consideration potential risks during the developmental stages of childhood, and thus, is more protective than the adult cancer slope factor. The equations used to derive the SSLs for vinyl chloride incorporate age adjustments for exposure and are presented in Equation 6. As vinyl chloride does not have an adsorption factor, dermal risks are not assessed.

Equation 6
Combined SSL for Vinyl Chloride
Residential Scenario

$$C_{vc-oral} = \frac{TR}{\left(\frac{CSF_o \times IFS_{adj} \times 10^{-6}}{AT_r}\right) + \left(\frac{CSF_o \times IRS_c \times 10^{-6}}{BW_c}\right)}$$

$$C_{vc-inh} = \frac{TR}{\left(\frac{IUR \times EF_r \times ED \times ET_{rs} \times 1000}{AT_r \times VF} + \left(\frac{IUR}{VF} \times 1000\right)\right)}$$

Combined Exposures:

$$SSL_{res-vc} = \frac{1}{\frac{1}{C_{vc-oral}} + \frac{1}{C_{vc-inh}}}$$

Parameter	Definition (units)	Default
$C_{vc\text{-}oral}$	Contaminant concentration (mg/kg)	Chemical-specific
$C_{vc\text{-}inh}$	Contaminant concentration (mg/kg)	Chemical-specific
$C_{res\text{-}vc}$	Combined SSL for vinyl chloride (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
BW_c	Body weight, child (kg)	15
AT_r	Averaging time, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
IFS_{adj}	Age-adjusted soil ingestion factor (mg/kg)	See Equation 4
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
IRS_c	Child soil ingestion factor (mg/day)	200
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
IUR	Inhalation unit risk $(\mu g/m^3)^{-1}$	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
ED	Exposure duration (yr)	26
ET_{rs}	Exposure time (hr/day x day/hr)	1
1000	Conversion factor (µg/mg)	1000
VF	Volatilization factor for soil (m^3/kg)	See Equation 44

Equations 7 through 12 show the derivation of the SSLs for carcinogenic chemicals exhibiting mutagenic properties. Mutagenicity is only assessed for the residential scenario.

Equation 7
SSL for Ingestion of Soil- Mutagens

$$C_{mu-oral} = \frac{TR \times AT_r}{CSF_o \times IFSM_{adj} \times 10^{-6}}$$

Parameter	Definition (units)	Default
$C_{mu\text{-}oral}$	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
$IFSM_{adj}$	Age-adjusted soil ingestion rate, mutagens (mg/kg)	See Equation 8
10^{-6}	Conversion factor (kg/mg)	10^{-6}

Equation 8
Calculation of Age-Adjusted Soil Ingestion Factor, Mutagens

$$IFSM_{adj} = \frac{EF_c \times ED_{0-2} \times IRS_c \times 10}{BW_c} + \frac{EF_c \times ED_{2-6} \times IRS_c \times 3}{BW_c} + \frac{EF_a \times ED_{6-16} \times IRS_a \times 3}{BW_a} + \frac{EF_a \times ED_{16-26} \times IRS_a \times 1}{BW_a}$$

Parameter	Definition (units)	Default
$IFSM_{adj}$	Age-adjusted soil ingestion factor for mutagens (mg/kg)	166,833
$ED_{0\text{-}2}$	Exposure duration, child (yr)	2
$ED_{2\text{-}6}$	Exposure duration, child (yr)	4
$ED_{6\text{-}16}$	Exposure duration, adult (yr)	10
$ED_{16\text{-}26}$	Exposure duration, adult (yr)	10
EF_c	Exposure frequency, child (days/yr)	350
EF_a	Exposure frequency, adult (days/yr)	350
IRS_c	Soil ingestion rate, child (mg/day)	200
IRS_a	Soil ingestion rate, adult (mg/day)	100
BW_c	Body weight, child (kg)	15
BW_a	Body weight, adult (kg)	80

Equation 9
SSL for Inhalation of Soil- Mutagens

$$C_{mu-inh} = \frac{TR \times AT_r}{(ET_{rs} \times 1000) \times [(ED_{0-2} \times EF \times IUR \times 10) + (ED_{2-6} \times EF \times IUR \times 3) + (ED_{6-16} \times EF \times IUR \times 3) + (ED_{16-26} \times EF \times IUR \times 1)] \times \left(\frac{1}{VF_s} + \frac{1}{PEF_w}\right)}$$

Parameter	Definition (units)	Default
$C_{mu\text{-}inh}$	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
IUR	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Chemical-specific
EF	Exposure frequency, (day/yr)	350
ED	Exposure duration (yr)	
	$ED_{0\text{-}2}$ (yr)	2
	$ED_{2\text{-}6}$ (yr)	4
	$ED_{6\text{-}16}$ (yr)	10
	$ED_{16\text{-}26}$ (yr)	10
ET_{rs}	Exposure time (hr/day x day/hr)	1
1000	Conversion factor (µg/mg)	1000
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 46
PEF	Particulate emission factor (m^3/kg)	See Equation 49

Equation 10
SSL for Dermal Contact with Soil- Mutagens

$$C_{mu-dermal} = \frac{TR \times AT_r}{\frac{CSF_o}{GIABS} \times DFSM_{adj} \times ABS_d \times 10^{-6}}$$

Parameter	Definition (units)	Default
$C_{mu\text{-}dermal}$	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
$DFSM_{adj}$	Age-adjusted soil contact factor, mutagens (mg/kg)	See Equation 11
ABS_d	Skin absorption factor (unitless)	Chemical-specific
10^{-6}	Conversion factor (kg/mg)	10^{-6}

Equation 11
Calculation of Age-Adjusted Soil Contact Factor, Mutagens

$$DFSM_{adj} = \frac{ED_{0-2} \times AF_c \times SA_c \times 10}{BW_c} + \frac{ED_{2-6} \times AF_c \times SA_c \times 3}{BW_c} + \frac{ED_{6-16} \times AF_a \times SA_a \times 3}{BW_a} + \frac{ED_{16-26} \times AF_a \times SA_a \times 1}{BW_a}$$

Parameter	Definition (units)	Default
$DFSM_{adj}$	Age-adjusted soil contact factor for mutagens (mg/kg)	475,599
ED_{0-2}	Exposure duration, child (yr) x EF (350 days/yr))	700
ED_{2-6}	Exposure duration, child (yr) x EF (350 days/yr))	1,400
ED_{6-16}	Exposure duration, adult (yr) x EF (350 days/yr))	3,500
ED_{16-26}	Exposure duration, adult (yr) x EF (350 days/yr))	3,500
AF_c	Soil adherence factor, child (mg/cm^2)	0.02
AF_a	Soil adherence factor, adult (mg/ cm^2)	0.07
SA_c	Exposed skin area, child, (cm^2/day)	2,690
SA_a	Exposed skin area, adult, (cm^2/day)	6,032
BW_c	Body weight, child (kg)	15
BW_a	Body weight, adult (kg)	80

The overall SSL for the residential scenario for mutagens is determined following Equation 12.

Equation 12
Determination of the Combined SSL
Mutagens

$$SSL_{res-mu} = \frac{1}{\frac{1}{C_{mu-oral}} + \frac{1}{C_{mu-inh}} + \frac{1}{C_{mu-dermal}}}$$

Parameter	Definition (units)	Default
SSL_{res-mu}	Cumulative SSL for mutagens (mg/kg)	Chemical-specific
$C_{mu-oral}$	Concentration from soil ingestion (mg/kg)	See Equation 7
C_{mu-inh}	Concentration from inhalation (mg/kg)	See Equation 9
$C_{mu-dermal}$	Concentration from dermal exposure (mg/kg	See Equation 10

For trichloroethylene (TCE), the US EPA IRIS (US EPA, 2016b) database provides data on both carcinogenity and mutagenicity. Mutagenic effects assessed include Non-Hodgkin's lymphoma (NHL), and impact to the liver and kidneys. The SSL equations for TCE present in Equations 13 through 18 allow assessment of both cancer and mutagenic effects.

Equation 13
SSL for Ingestion of Soil - Trichloroethylene (TCE)
Residential Scenario

$$C_{TCE-oral} = \frac{TR \times AT}{\left(CSF_o \times 10^{-6} \times \left(\left(CAF_o \times IFS_{adj}\right) + \left(MAF_o \times IFSM_o\right)\right)\right)}$$

Parameter	Definition (units)	Default
$C_{TCE-oral}$	Contaminant concentration, ingestion soil (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
CAF_o	Adjusted oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	See Equation 14
IFS_{adj}	Age-adjusted soil ingestion factor for carcinogens (mg/kg)	See Equation 7
MAF_o	Adjusted oral mutagenic slope factor $(mg/kg\text{-}day)^{-1}$	See Equation 14
$IFSM_o$	Age-adjusted soil ingestion factor for mutagens (mg/kg)	See Equation 8

Equation 14
Adjusted Oral Slope Factors - TCE
Residential Scenario

$$CAF_o = \frac{CSF_{o-NHL+Liver}}{CSF_{adult}}$$

$$MAF_o = \frac{CSF_{o-kidney}}{CSF_{adult}}$$

Parameter	Definition (units)	Default
CAF_o	Adjusted oral cancer slope factor	0.804
CSF_{adult}	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	0.046
$CSF_{o\text{-}NHL+liver}$	Oral cancer slope factor, NHL (2.16E-02) and Liver (1.55E-02), $(mg/kg\text{-}day)^{-1}$	0.0370
MAF_o	Adjusted oral mutagenic slope factor	0.202
$CSF_{o\text{-}kidney}$	Oral cancer slope factor, kidney $(mg/kg\text{-}day)^{-1}$	0.00933

Equation 15
SSL for Inhalation of Soil- TCE

$$C_{mu-inh} = \frac{TR \times AT_r}{IUR \times \left(\frac{1}{VF_s} + \frac{1}{PEF}\right) \times 1000 \times (1/24) \times \left[(CAF_i \times EF \times ED_r \times ET_r) + (seebelow)\right]}$$

$$\left[(ED_{0-2} EF_{0-2} \times ET_{0-2} \times MAF_i \times 10) + (ED_{2-6} EF_{2-6} \times ET_{2-6} \times MAF_i \times 3) + (ED_{6-16} EF_{6-16} \times ET_{6-16} \times MAF_i \times 3) + (ED_{16-26} EF_{16-26} \times ET_{16-26} \times MAF_i \times 1)\right]$$

Parameter	Definition (units)	Default
$C_{TCE\text{-}inh}$	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
IUR	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Chemical-specific
EF	Exposure frequency, (day/yr)	350
ED	Exposure duration (day)	
	$ED_{0\text{-}2}$ (yr)	2
	$ED_{2\text{-}6}$ (yr)	4
	$ED_{6\text{-}16}$ (yr))	10
	$ED_{16\text{-}26}$ (yr)	10
	ED_r (yr)	26
ET_r	Exposure time (hr/day)	1
1000	Conversion factor (µg/mg)	1000
1/24	Conversion factor (day/hr)	1/24
CAF_i	Adjusted inhalation cancer unit risk $(\mu g/m^3)^{-1}$	See Equation 16
MAF_i	Adjusted inhalation mutagenic unit risk $(\mu g/m^3)^{-1}$	See Equation 16
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 46
PEF	Particulate emission factor (m^3/kg)	See Equation 49

Equation 16
Adjusted Inhalation Unit Risks - TCE
Residential Scenario

$$CAF_i = \frac{IUR_{NHL+Liver}}{IUR_{adult}}$$

$$MAF_i = \frac{IUR_{kidney}}{IUR_{adult}}$$

Parameter	Definition (units)	Default
CAF_i	Adjusted carcinogenic inhalation unit risk $(\mu g/m^3)^{-1}$	0.756
IUR_{adult}	Inhalation unit risk, $(\mu g/m^3)^{-1}$	4.1E-06
$IUR_{NHL+liver}$	Inhalation unit risk, NHL (2E-06) and Liver (1E-06), $(\mu g/m^3)^{-1}$	3.1E-06
MAF_i	Adjusted mutagenic inhalation unit risk $(\mu g/m^3)^{-1}$	0.244
IUR_{kidney}	Inhalation unit risk, kidney, $(\mu g/m^3)^{-1}$	1E-06

Equation 17
SSL for Dermal Contact with Soil - Trichloroethylene (TCE)
Residential Scenario

$$C_{TCE-der} = \frac{TR \times AT}{\frac{CSF_o}{GIABS} \times 10^{-6} \times \left(\left(CAF_o \times DFS_{adj} \times ABS\right) + \left(MAF_o \times DFSM_{adj} \times ABS\right)\right)}$$

Parameter	Definition (units)	Default
$C_{TCE-der}$	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
GIABS	Fraction of contaminant absorbed in gastrointestinal tract (unitless)	Chemical-specific
10^{-6}	Unit conversion factor (kg/mg)	1E-06
CAF_o	Adjusted oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	See Equation 14
DFS_{adj}	Resident soil dermal contact factor- age-adjusted (mg/kg)	See Equation 5
ABS	Skin absorption factor (unitless)	Chemical-specific
MAF_o	Oral mutagenic slope factor $(mg/kg\text{-}day)^{-1}$	See Equation 14
$DFSM_{adj}$	Resident Mutagenic soil dermal contact factor- age-adjusted (mg/kg)	See Equation 11

Equation 18
Determination of the Combined SSL
TCE

$$SSL_{res-TCE} = \frac{1}{\frac{1}{C_{TCE-oral}} + \frac{1}{C_{TCE-inh}} + \frac{1}{C_{TCE-der}}}$$

Parameter	Definition (units)	Default
$SSL_{res\text{-}TCE}$	Cumulative SSL for mutagens (mg/kg)	Chemical-specific
$C_{TCE\text{-}oral}$	Concentration from soil ingestion (mg/kg)	See Equation 13
$C_{TCE\text{-}inh}$	Concentration from inhalation (mg/kg)	See Equation 15
$C_{TCE\text{-}der}$	Concentration from dermal exposure (mg/kg)	See Equation 17

2.3 Soil Screening Levels for Non-residential Land Uses

Non-residential land uses encompass all commercial and industrial land uses and focus on two very different receptors – a commercial/industrial worker and a construction worker. Unlike those calculated for residential land-uses, NMED SSLs for non-residential land uses are based solely on exposures to adults. Consequently, exposures to carcinogens are not age-adjusted. Due to the wide range of activities and exposure levels a non-residential receptor may be exposed to during various work-related activities, it is important to ensure that the default exposure parameters are representative of site-specific conditions. Table 2-5 provides a summary of the exposure characteristics and parameters for non-residential land use receptors (US EPA, 2014a).

Table 2-5. Summary of Non-Residential Land Use Receptors

Receptor	Commercial/Industrial Worker	Construction Worker
Exposure Characteristics	• Substantial soil exposures • High soil ingestion rate • Long-term exposure • Exposure to surface and shallow subsurface soils (0-1 foot bgs) • Adult-only exposure	• Exposed during construction activities only • Short-term exposure • Very high soil ingestion and dust inhalation rates • Exposure to surface and subsurface soils (0-10 feet bgs)
Default Exposure Parameters		
Exposure frequency (days/yr)	225	250
Exposure duration (yr)	25	1
Soil ingestion rate (mg/day)	100	330
Body Weight (kg)	80	80
Skin surface area exposed (cm^2)	3,470	3,470
Skin-soil adherence factor (mg/ cm^2)	0.12	0.3

2.3.1 Commercial/Industrial Worker

The commercial/industrial scenario is considered representative of on-site workers who spend all or most of their workday outdoors. A commercial/industrial worker is assumed to be a long-term receptor exposed during the course of a workday as either (1) a full-time employee of a company operating on-site who spends most of the workday conducting maintenance or manual labor activities outdoors or (2) a worker who is assumed to regularly perform grounds-keeping activities as part of his/her daily responsibilities. Exposure to surface and shallow subsurface soils (i.e., at depths of zero to 1 ft bgs) is expected to occur during moderate digging associated with routine maintenance and grounds-keeping activities. A commercial/industrial receptor is expected to be the most highly exposed receptor in the outdoor environment under generic or day-to-day commercial/industrial conditions. Thus, the screening levels for this receptor are expected to be protective of other reasonably anticipated indoor and outdoor workers at a commercial/industrial facility. However, screening levels developed for the commercial/industrial worker may not be protective of a construction worker due to the latter's increased soil contact rate during construction activities. In addition, the SSLs for the commercial/industrial worker do not account for inhalation of volatiles indoors via vapor intrusion.

Equations 19 and 20 were used to develop generic SSLs for cumulative exposure to carcinogenic and noncarcinogenic contaminants by all exposure pathways. Default exposure parameters (US EPA 2002a and US EPA 2014a) are provided and were used in calculating the NMED SSLs.

Equation 19
Combined Exposures to Carcinogenic Contaminants in Soil
Commercial/Industrial Scenario

$$C_{CI-oral} = \frac{TR \times AT_{CI} \times BW_{CI}}{CSF_o \times EF_{CI} \times ED_{CI} \times IR_{CI} \times 10^{-6}}$$

$$C_{CI-inh} = \frac{TR \times AT_{CI}}{IUR \times 1000 \times EF_{CI} \times \left(\frac{1}{VF_s} + \frac{1}{PEF_w}\right) \times ED_{CI} \times ET_{CI}}$$

$$C_{CI-dermal} = \frac{TR \times AT_{CI} \times BW_{CI}}{EF_{CI} \times ED_{CI} \times \frac{CSF_o}{GIABS} \times SA_{CI} \times AF_{CI} \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{CI} = \frac{1}{\frac{1}{C_{CI-oral}} + \frac{1}{C_{CI-inh}} + \frac{1}{C_{CI-dermal}}}$$

Parameter	Definition (units)	Default
$C_{CI\text{-}oral}$	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
$C_{CI\text{-}dermal}$	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
$C_{CI\text{-}inh}$	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{CI}	Contaminant concentration, all pathways (mg/kg)	Chemical-specific
TR	Target Risk	1E-05
BW_{CI}	Body weight, adult (kg)	80
AT_{CI}	Averaging time, carcinogens (days)	25,550
EF_{CI}	Exposure frequency, commercial/industrial (day/yr)	225
ED_{CI}	Exposure duration, commercial/industrial (yr)	25
IR_{CI}	Soil ingestion rate, commercial/industrial (mg/day)	100
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
SA_{CI}	Dermal surface area, commercial/industrial (cm^2/day)	3,470
AF_{CI}	Soil adherence factor, commercial/industrial (mg/cm^2)	0.12
ABS_d	Skin absorption factor (unitless)	Chemical-specific
ET_{CI}	Exposure time, commercial/industrial (8 hr/per 24 hr)	0.33
IUR	Inhalation unit risk $(\mu g/m^3)^{-1}$	Chemical-specific
1000	Unit conversion (µg/mg)	1000
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 46
PEF	Particulate emission factor (m^3/kg)	See Equation 49

Equation 20
Combined Exposures to Noncarcinogenic Contaminants in Soil
Commercial/Industrial Scenario

$$C_{CI-oral} = \frac{THQ \times AT_{CI} \times BW_a}{EF_{CI} \times ED_{CI} \times (1/RfD_o) \times IR_{CI} \times (10^{-6})}$$

$$C_{CI-inh} = \frac{THQ \times AT_{CI}}{EF_{CI} \times ED_{CI} \times ET_{CI} \times (1/RfC) \times [(1/VF_s) + (1/PEF_w)]}$$

$$C_{CI-dermal} = \frac{THQ \times AT_{CI} \times BW_a}{EF_{CI} \times ED_{CI} \times [1/(RfD_o \times GIABS)] \times SA_{CI} \times AF_{CI} \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{CI} = \frac{1}{\frac{1}{C_{CI-oral}} + \frac{1}{C_{CI-inh}} + \frac{1}{C_{CI-dermal}}}$$

Parameter	Definition (units)	Default
$C_{CI\text{-}oral}$	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
$C_{CI\text{-}dermal}$	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
$C_{CI\text{-}inh}$	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{CI}	Soil screening level, all pathways (mg/kg)	Chemical-specific
THQ	Target hazard quotient	1
BW_a	Body weight, adult (kg)	80
AT_{CI}	Averaging time, noncarcinogens (days)	ED x 365
EF_{CI}	Exposure frequency, commercial/industrial (day/yr)	225
ED_{CI}	Exposure duration, commercial/industrial (yr)	25
IR_{CI}	Soil ingestion rate, commercial/industrial (mg/day)	100
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
RfD_o	Oral reference dose (mg/kg-day)	Chemical-specific
SA_{CI}	Dermal surface area, commercial/industrial (cm^2/day)	3,470
AF_{CI}	Soil adherence factor, commercial/industrial (mg/cm^2)	0.12
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
ABS_d	Skin absorption factor (unitless)	Chemical-specific
ET_{CI}	Exposure time (8 hr/day per 1 day/24 hr)	0.33
RfC	Reference concentration (mg/m^3)	Chemical-specific
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 46
PEF	Particulate emission factor (m^3/kg)	See Equation 49

2.3.2 Construction Worker

A construction worker is assumed to be a receptor that is exposed to contaminated soil during the workday for the duration of a single on-site construction project. If multiple construction projects are anticipated, it is assumed that different workers will be employed for each project. The activities for this receptor typically involve substantial exposures to surface and subsurface soils (i.e., at depths of zero to 10 feet bgs) during excavation, maintenance, and building construction projects (intrusive operations). A construction worker is assumed to be exposed to contaminants via the following pathways: incidental soil ingestion, dermal contact with soil, and inhalation of contaminated outdoor air (volatile and particulate emissions). While a construction worker receptor is assumed to have a higher soil ingestion rate than a commercial/industrial worker due to the type of activities performed during construction projects, the exposure frequency and duration are assumed to be significantly shorter due to the short-term nature of construction projects. However, chronic toxicity information was used when developing screening levels for a construction worker receptor. This approach is significantly more conservative than using sub-chronic toxicity data because it combines the higher soil exposures for construction workers with chronic toxicity criteria. Equations 21 and 22 were used to develop generic SSLs for cumulative exposure to carcinogenic and noncarcinogenic contaminants by all exposure pathways for a construction worker. Default exposure parameters (US EPA 2002a and US EPA 2014a) are provided and were used in calculating the NMED SSLs.

Equation 21
Combined Exposures to Carcinogenic Contaminants in Soil
Construction Worker Scenarios

$$C_{CW-oral} = \frac{TR \times AT_{CW} \times BW_{CW}}{CSF_o \times EF_{CW} \times ED_{CW} \times IR_{CW} \times 10^{-6}}$$

$$C_{CW-inh} = \frac{TR \times AT_{CW}}{IUR \times 1000 \times EF_{CW} \times \left(\frac{1}{VF_{cw}} + \frac{1}{PEF_{cw}}\right) \times ED_{CW} \times ET_{CW}}$$

$$C_{CW-dermal} = \frac{TR \times AT_{CW} \times BW_{CW}}{EF_{CW} \times ED_{CW} \times \frac{CSF_o}{GIABS} \times SA_{CW} \times AF_{CW} \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{CW} = \frac{1}{\frac{1}{C_{CW-oral}} + \frac{1}{C_{CW-inh}} + \frac{1}{C_{CW-dermal}}}$$

Parameter	Definition (units)	Default
$C_{CW\text{-}oral}$	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
$C_{CW\text{-}dermal}$	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
$C_{CW\text{-}inh}$	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{CW}	Contaminant concentration, all pathways (mg/kg)	Chemical-specific
TR	Target Risk	1E-05
BW_{CW}	Body weight, adult (kg)	80
AT_{CW}	Averaging time, carcinogens (days)	25,550
EF_{CW}	Exposure frequency, construction worker (day/yr)	250
ED_{CW}	Exposure duration, construction worker (years)	1
IR_{CW}	Soil ingestion rate, construction worker (mg/day)	330
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
SA_{CW}	Dermal surface area, construction worker (cm^2/day)	3,470
AF_{CW}	Soil adherence factor, construction worker (mg/cm^2)	0.3
ABS_d	Skin absorption factor (unitless)	Chemical-specific
ET_{CW}	Exposure time, construction worker (8 hours/day per 1 day/24 hours)	0.33
IUR	Inhalation unit risk $(\mu g/m^3)^{-1}$	Chemical-specific
1000	Unit conversion (µg/mg)	1000
VF_{cw}	Volatilization factor for soil, construction worker (m^3/kg)	See Equation 47
PEF_{cw}	Particulate emission factor, construction worker (m^3/kg)	See Equation 50

Equation 22
Combined Exposures to Noncarcinogenic Contaminants in Soil
Construction Worker Scenario

$$C_{CW-oral} = \frac{THQ \times AT_{CW} \times BW_{CW}}{EF_{CW} \times ED_{CW} \times (1/RfD_o) \times IR_{CW} \times (10^{-6})}$$

$$C_{CW-inh} = \frac{THQ \times AT_{CI}}{EF_{CW} \times ED_{CW} \times ET_{CW} \times (1/RfC) \times [(1/VF_{cw}) + (1/PEF_{cw})]}$$

$$C_{CW-dermal} = \frac{THQ \times AT_{CW} \times BW_{cw}}{EF_{CW} \times ED_{CW} \times [1/(RfD_o \times GIABS)] \times SA_{CW} \times AF_{CW} \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{CW} = \frac{1}{\frac{1}{C_{CW-oral}} + \frac{1}{C_{CW-inh}} + \frac{1}{C_{CW-dermal}}}$$

Parameter	Definition (units)	Default
$C_{CW\text{-}oral}$	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
$C_{CW\text{-}dermal}$	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
$C_{CW\text{-}inh}$	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{CW}	Soil screening level, all pathways (mg/kg)	Chemical-specific
THQ	Target hazard quotient	1
BW_{cw}	Body weight, adult (kg)	80
AT_{CW}	Averaging time, noncarcinogens (days)	ED x 365
EF_{CW}	Exposure frequency, construction worker (day/yr)	250
ED_{CW}	Exposure duration, construction worker (years)	1
IR_{CW}	Soil ingestion rate, construction worker (mg/day)	330
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
RfD_o	Oral reference dose (mg/kg-day)	Chemical-specific
SA_{CW}	Dermal surface area, construction worker (cm^2/day)	3,470
AF_{CW}	Soil adherence factor, construction worker (mg/cm^2)	0.3
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
ABS_d	Skin absorption factor (unitless)	Chemical-specific
ET_{CW}	Exposure time (8 hours/day per 1 day/24 hour)	0.33
RfC	Reference concentration (mg/m^3)	Chemical-specific
VF_{cw}	Volatilization factor for soil, construction worker (m^3/kg)	See Equation 47
PEF_{cw}	Particulate emission factor, construction worker (m^3/kg)	See Equation 50

2.4 Tap Water Screening Levels

Exposure to contaminants can occur through the ingestion of and dermal contact with domestic/household water and inhalation of volatiles in domestic/household water. NMED tap water screening levels were developed for residential land-use only. If it is determined that commercial/industrial receptors are potentially exposed to contaminated water through ingestion, dermal contact, and/or inhalation, these pathways must be evaluated via the methods outlined in this document and utilizing appropriate exposure parameters. The calculations of the NMED tap water screening levels for domestic water are based upon the methodology presented in RAGS, Part B (US EPA 1991), Part E (US EPA, 2004) and the revised default exposure factors (US EPA, 2014a). The screening levels are based upon ingestion of and dermal contact with contaminants in water, and inhalation of volatile contaminants volatilized from water during domestic use. To estimate the exposure dose from dermal contact with tap water, the skin permeability coefficient (K_p) and absorbed dose per event (DA_{event}) were considered, as outlined in US EPA's (2004a) RAGS Part E. While ingestion and dermal contact were considered for all chemicals, inhalation of volatiles from water was considered for those chemicals with a minimum Henry's Law constant of approximately 1E-05 atm-m^3/mole and with a maximum molecular weight of approximately 200 g/mole. To address the groundwater-to-air pathways, the tap water screening levels incorporate a volatilization factor (K) of 0.5 liters per cubic meter (L/m^3) for volatile contaminants (US EPA, 1991); this derived value defines the relationship between the concentration of a contaminant in household water and the average concentration of the volatilized contaminant in air as a result of all uses of household water (i.e., showering, laundering, dish washing).

As ingestion, dermal contact, and inhalation rates may be different for children and adults, carcinogenic risks were calculated using age-adjusted factors, which were obtained from RAGS, Part B (US EPA 1991) and Part E (US EPA, 2004a). Equations 23 through 29 show how SLs for carcinogenic and noncarcinogenic contaminants were developed. Similar to soil, separate equations are used for vinyl chloride (Equations 30 and 31) and carcinogens exhibiting mutagenic toxicity (Equations 32-36) such as trichloroethylene.

Equation 23
Combined Exposures to Carcinogenic Contaminants in Tap Water
Residential Scenario

$$C_{oral} = \frac{TR \times AT_c \times 1000}{CSF_o \times IFW_{adj}}$$

C_{derm} = See Equations 24 - 26

$$C_{inh} = \frac{TR \times AT_c}{EF_r \times ED_r \times ET_{rw} \times IUR \times K}$$

Combined Exposures:

$$SL_{tap} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{derm}} + \frac{1}{C_{inh}}}$$

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration, ingestion (µg/L)	Chemical-specific
C_{derm}	Contaminant concentration, dermal (µg/L) (See Equations 25-27)	Chemical-Specific
C_{inh}	Contaminant concentration, inhalation (µg/L)	Chemical-specific
SL_{tap}	Tap water screening level (µg/L)	Chemical-specific
TR	Target risk	1E-05
AT_c	Averaging time, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
1000	Unit conversion (µg/mg)	1000
IFW_{adj}	Age-adjusted water ingestion rate, resident (L /kg) (See Equation 24)	328
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
ED_r	Exposure duration (yr)	26
ET_{rw}	Exposure time, resident, tap water (24 hr/day per 1day/24 hr)	1
IUR	Inhalation unit risk $(\mu g/m^3)^{-1}$	Chemical-specific
K	Andelman volatilization factor (L/m^3)	0.5

Equation 24
Calculation of Age-Adjusted Tap Water Ingestion Factor

$$IFW_{adj} = \frac{EF \times ED_c \times IRW_c}{BW_c} + \frac{EF \times (ED_r - ED_c) \times IRW_a}{BW_a}$$

Parameter	Definition (units)	Default
IFW_{adj}	Age-adjusted water ingestion factor for carcinogens (L/kg)	328
EF	Exposure frequency (day/yr)	350
ED_c	Exposure duration, child (yr)	6
IRW_c	Water ingestion rate, child (L/day)	0.78
BW_c	Body weight, child (kg)	15
ED_r	Exposure duration, resident adult (yr)	26
ED_c	Exposure duration, resident child (yr)	6
IRW_a	Water ingestion rate, adult (L/day)	2.5
BW_a	Body weight, adult (kg)	80

Equation 25
Dermal Exposure to Carcinogenic Contaminants in Tap Water
Residential Scenario

For inorganic constituents:

$$C_{derm} = \frac{DA_{event\_carc} \times 1000\ (cm^3/L)}{K_p \times t_{event\_adj}}$$

For organic constituents:

If $t_{event\_adj} \leq t^*$, then:

$$C_{derm} = \frac{DA_{event\_carc} \times 1000\ (cm^3/L)}{2 \times FA \times K_p \times \sqrt{\frac{6\tau_{event} \times t_{event\_adj}}{\pi}}}$$

If $t_{event\_adj} > t^*$, then:

$$C_{derm} = \frac{DA_{event\_carc} \times 1000\ (cm^3/L)}{FA \times K_p \times \left[\frac{t_{event\_adj}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event\_carc} = \frac{TR \times AT_c \times 1000(\mu g/mg)}{\left(\frac{CSF_o}{GIABS}\right) \times DFW_{adj}}$$

Parameter	Definition (units)	Default
C_{derm}	Contaminant concentration, dermal (µg/L)	Chemical-specific
DA_{event_carc}	Absorbed dose per event, carcinogens (mg/cm^2-event)	Chemical-specific
K_p	Dermal permeability coefficient of compound in water (cm/hr)	Chemical-specific
$t_{event\text{-}adj}$	Age-adjusted dermal exposure time per event, resident (hr/event)	See Equation 26
t*	Time to reach steady state (hr)	2.4 x τ_{event}
FA	Fraction absorbed water (unitless)	Chemical-specific
τ_{event}	Lag time per event (hr/event)	Chemical-specific
B	Ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless)	Chemical-specific
TR	Target risk	1E-05
AT_c	Averaging time, resident, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
DFW_{adj}	Age-adjusted dermal exposure factor, water, resident (cm^2-event /kg)	See Equation 27

Equation 26
Calculation of Age-adjusted Dermal Exposure Time per Event, Tap Water Residential Scenario

$$t_{event\_adj} = \frac{\left(t_{event\_c} \times ED_c\right) + \left(t_{event\_a} \times (ED_r - ED_c)\right)}{ED_r}$$

Parameter	Definition (units)	Default
t_{event_adj}	Age-adjusted dermal exposure time per event, resident (hr/event)	0.6708
t_{event_c}	Dermal exposure time per event, child (hr/event)	0.54
t_{event_a}	Dermal exposure time per event, adult (hr/event)	0.71
ED_c	Exposure duration, child (yr)	6
ED_r	Exposure duration, resident (yr)	26

Equation 27
Calculation of Age-adjusted Dermal Exposure Factor, Tap Water Residential Scenario

$$DFW_{adj} = \left(\frac{EF \times EV_c \times ED_c \times SA_c}{BW_c}\right) + \left(\frac{EF \times EV_a \times ED_a \times SA_a}{BW_a}\right)$$

Parameter	Definition (units)	Default
DFW_{adj}	Age-adjusted dermal exposure factor, tap water, resident (cm^2-event /kg)	2,610,650
EF	Exposure frequency (day/yr)	350
EV_c	Event frequency, child (events/day)	1
ED_c	Exposure duration, child (yr)	6
SA_c	Skin surface area available for water contact, child (cm^2)	6,365
BW_c	Body weight, child (kg)	15
EV_a	Event frequency, adult (events/day)	1
ED_a	Exposure duration, adult (yr)	20
SA_a	Skin surface area available for water contact, adult (cm^2)	19,652
BW_a	Body weight, adult (kg)	80

Equation 28
Combined Exposures to Noncarcinogenic Contaminants in Tap Water
Residential Scenario

$$C_{oral} = \frac{THQ \times BW_c \times 1000 \times AT_{nc}}{EF_r \times ED_c \times \left(\frac{1}{RfD_o}\right) \times IRW_c}$$

$$C_{derm} = See\ Equation\ 22$$

$$C_{inh} = \frac{THQ \times AT_{nc} \times 1000}{EF_r \times ED_c \times ET_{rw} \times \left(\frac{1}{RfC}\right) \times K}$$

Combined Exposures:

$$SL_{tap} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{inh}} + \frac{1}{C_{derm}}}$$

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration, ingestion (µg/L)	Chemical-specific
C_{derm}	Contaminant concentration, dermal (µg/L)	See Equation 29
C_{inh}	Contaminant concentration, inhalation (µg/L)	Chemical-specific
SL_{tap}	Tap water screening level (µg/L)	Chemical-specific
THQ	Target hazard quotient	1
BW_c	Body weight, child (kg)	15
AT_{nc}	Averaging time, noncarcinogens (days)	ED_c x 365
1000	Unit conversion (µg/mg)	1000
EF_r	Exposure frequency, resident (day/yr)	350
ED_c	Exposure duration, child resident (yr)	6
IRW_a	Water ingestion rate, child resident (L/day)	0.78
RfD_o	Oral reference dose(mg/kg-day)	Chemical-specific
ET_{rw}	Exposure time (24 hr/day per 1day/24 hr)	1
RfC	Reference concentration (mg/m^3)	Chemical-specific
K	Andelman volatilization factor (L/m^3)	0.5

Equation 29
Dermal Exposure to Noncarcinogenic Contaminants in Tap Water
Residential Scenario

For inorganic constituents:

$$C_{derm} = \frac{DA_{event\_nc} \times 1000\ (cm^3/L)}{K_p \times t_{event\_c}}$$

For organic constituents:

If $t_{event\_c} \leq t^*$, then:

$$C_{derm} = \frac{DA_{event\_nc} \times 1000\ (cm^3/L)}{2 \times FA \times K_p \times \sqrt{\frac{6\tau_{event} \times t_{event\_c}}{\pi}}}$$

If $t_{event\_c} > t^*$, then:

$$C_{derm} = \frac{DA_{event\_nc} \times 1000\ (cm^3/L)}{FA \times K_p \times \left[\frac{t_{event\_c}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event\_nc} = \frac{THQ \times AT_{nc} \times 1000(\mu g/mg) \times BW_c}{\left(\frac{1}{RfD_o \times GIABS}\right) \times EV_c \times ED_c \times EF_r \times SA_c}$$

Parameter	Definition (units)	Default
C_{derm}	Contaminant concentration, dermal (µg/L)	Chemical-specific
DA_{event_nc}	Absorbed dose per event, noncarcinogens (µg/cm^2-event)	Chemical-specific
K_p	Dermal permeability coefficient of compound in water (cm/hr)	Chemical-specific
t_{event_c}	Dermal exposure time per event, child (hr/event)	1
t*	Time to reach steady state (hr)	2.4 x τ_{event}
FA	Fraction absorbed water (unitless)	Chemical-specific
τ_{event}	Lag time per event (hr/event)	Chemical-specific
B	Ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless)	Chemical-specific
THQ	Target hazard quotient	1
AT_{nc}	Averaging time, resident, noncarcinogens (days)	365 x ED_c
BW_c	Body weight, child (kg)	15
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
RfD_o	Oral reference dose (mg/kg-day)	Chemical-specific
EV_c	Event frequency, child (events/day)	1
ED_c	Exposure duration, child (yr)	6
EF_r	Exposure frequency, resident (day/yr)	350
SA_c	Skin surface area available for contact, child (cm^2)	6,365

Equation 30
Combined Carcinogenic Exposures to Vinyl Chloride in Tap Water
Residential Scenario

$$C_{oral} = \frac{TR}{\left(\frac{CSF_o \times IFW_{adj} \times 0.001}{AT} + \frac{CSF_o \times IRW_c \times 0.001}{BW_c}\right)}$$

$$C_{derm} = See\ Equation\ 30$$

$$C_{inh} = \frac{TR}{\left(\frac{IUR \times EF_r \times ED_r \times ET_{rw} \times K}{AT} + (IUR \times K)\right)}$$

Combined Exposures:

$$SL_{tap} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{inh}} + \frac{1}{C_{derm}}}$$

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration, ingestion (µg/L)	Chemical-specific
C_{derm}	Contaminant concentration, dermal (µg/L)	See Equation 31
C_{inh}	Contaminant concentration, inhalation (µg/L)	Chemical-specific
SL_{tap}	Tap water screening level (µg/L)	Chemical-specific
TR	Target risk	1E-05
AT	Averaging time, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
0.001	Unit conversion (mg/µg)	0.001
IFW_{adj}	Age-adjusted water ingestion rate, resident (L/kg)	See Equation 24
IRW_c	Child water ingestion rate, resident (L/day)	1
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
ED_r	Exposure duration (yr)	26
ET_{rw}	Exposure time (24 hours/day per 1day/24 hr)	1
IUR	Inhalation unit risk $(\mu g/m^3)^{-1}$	Chemical-specific
K	Andelman volatilization factor (L/m^3)	0.5

Equation 31
Carcinogenic Dermal Exposure to Vinyl Chloride in Tap Water
Residential Scenario

If $t_{event\_adj} \leq t^*$, then:

$$C_{derm} = \frac{DA_{event\_vc} \times 1000\ (cm^3/L)}{2 \times FA \times K_p \times \sqrt{\frac{6\tau_{event} \times t_{event\_adj}}{\pi}}}$$

If $t_{event\_adj} > t^*$, then:

$$C_{derm} = \frac{DA_{event\_vc} \times 1000\ (cm^3/L)}{FA \times K_p \times \left[\frac{t_{event\_adj}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event\_vc} = \frac{TR}{\left[\frac{\left(\frac{CSF_o}{GIABS}\right) \times DFW_{adj}}{AT_r \times 1000\frac{\mu g}{mg}}\right] + \left[\frac{\left(\frac{CSF_o}{GIABS}\right) \times EV_c \times SA_c}{BW_c \times 1000\frac{\mu g}{mg}}\right]}$$

Parameter	Definition (units)	Default
t_{event_adj}	Age-adjusted dermal exposure time per event, resident (hr/event)	See Equation 26
t^*	Time to reach steady state (hr)	2.4 x τ_{event}
τ_{event}	Lag time per event (hr/event)	Chemical-specific
C_{derm}	Contaminant concentration, dermal (µg/L)	Chemical-specific
DA_{event_vc}	Absorbed dose per event, vinyl chloride (µg/cm^2-event)	Chemical-specific
FA	Fraction absorbed water (unitless)	Chemical-specific
K_p	Dermal permeability coefficient of compound in water (cm/hr)	Chemical-specific
B	Ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless)	Chemical-specific
TR	Target risk	1E-05
AT_r	Averaging time, resident, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
DFW_{adj}	Age-adjusted dermal exposure factor, tap water, resident (cm^2-event /kg)	See Equation 27
EV_c	Event duration, child (events/day)	1
SA_c	Skin surface area available for contact, child (cm^2)	6,365
BW_c	Body weight, child (kg)	15

Equation 32
Combined Exposures to Mutagenic Contaminants in Tap Water
Residential Exposure

$$C_{mu-oral} = \frac{TR \times AT_r \times 1000}{CSF_o \times IFWM_{adj}}$$

$$C_{mu-derm} = See\ Equations\ 27-29$$

$$C_{mu-inh} = \frac{TR \times AT_r}{(EF_r \times ET_{rs} \times K) \times [(ED_{0-2} \times IUR \times 10) + (ED_{2-6} \times IUR \times 3) + (ED_{6-16} \times IUR \times 3) + (ED_{16-26} \times IUR \times 1)]}$$

Combined Exposures:

$$SL_{tap-mu} = \frac{1}{\frac{1}{C_{mu-oral}} + \frac{1}{C_{mu-inh}} + \frac{1}{C_{mu-derm}}}$$

Parameter	Definition (units)	Default
$C_{mu\text{-}oral}$	Contaminant concentration, ingestion (µg/L)	Chemical-specific
$C_{mu\text{-}derm}$	Contaminant concentration, dermal (µg/L)	See Equations 34-36
$C_{mu\text{-}inh}$	Contaminant concentration, inhalation (µg/L)	Chemical-specific
$SL_{tap\text{-}mu}$	Tap water screening level (µg/L)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
ET_{rw}	Exposure time (24 hr/day per 1day/24 hr)	1
K	Andelman volatilization factor (L/m^3)	0.5
$IFWM_{adj}$	Age-adjusted water ingestion rate, mutagens (L/kg)	See Equation 33
1000	Conversion factor (µg/mg)	1000
$ED_{0\text{-}2}$	Exposure duration, child (yr)	2
$ED_{2\text{-}6}$	Exposure duration, child (yr)	4
$ED_{6\text{-}16}$	Exposure duration, adult (yr)	10
$ED_{16\text{-}26}$	Exposure duration, adult (yr)	10
IUR	Inhalation unit risk $(\mu g/m^3)^{-1}$	Chemical-specific

Equation 33
Calculation of Age-Adjusted Tap Water Ingestion Factor, Mutagens

$$IFWM_{adj} = \frac{EF \times ED_{0-2} \times IRW_c \times 10}{BW_c} + \frac{EF \times ED_{2-6} \times IRW_c \times 3}{BW_c} + \frac{EF \times ED_{6-16} \times IRW_a \times 3}{BW_a} + \frac{EF \times ED_{16-26} \times IRW_a \times 1}{BW_a}$$

Parameter	Definition (units)	Default
$IFWM_{adj}$	Age-adjusted water ingestion factor for mutagens (L/kg)	1,019.9
ED_{0-2}	Exposure duration, child (yr)	2
ED_{2-6}	Exposure duration, child (yr)	4
ED_{6-16}	Exposure duration, adult (yr)	10
ED_{16-26}	Exposure duration, adult (yr)	10
EF	Exposure frequency (days/yr)	350
IRW_c	Water ingestion rate, child (L/day)	0.78
IRW_a	Water ingestion rate, adult (L/day)	2.5
BW_c	Body weight, child (kg)	15
BW_a	Body weight, adult (kg)	80

Equation 34
Dermal Exposure to Mutagenic Contaminants in Tap Water
Residential Scenario

For inorganic constituents:

$$C_{mu-derm} = \frac{DA_{event\_mu} \times 1000\ (cm^3/L)}{K_p \times t_{event\_mu\_adj}}$$

For organic constituents:

If $t_{event\_mu\_adj} \leq t^*$, then:

$$C_{mu-derm} = \frac{DA_{event\_mu} \times 1000\ (cm^3/L)}{2 \times FA \times K_p \times \sqrt{\frac{6\tau_{event} \times t_{event\_mu\_adj}}{\pi}}}$$

If $t_{event\_mu\_adj} > t^*$, then:

$$C_{mu-derm} = \frac{DA_{event\_mu} \times 1000\ (cm^3/L)}{FA \times K_p \times \left[\frac{t_{event\_mu\_adj}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event\_mu} = \frac{TR \times AT_r \times 1000(\mu g/mg)}{\left(\frac{CSF_o}{GIABS}\right) \times DFW_{mu\_adj}}$$

Parameter	Definition (units)	Default
$C_{mu\text{-}derm}$	Contaminant concentration, mutagens, dermal (µg/L)	Chemical-specific
DA_{event_mu}	Absorbed dose per event, mutagens (µg/cm^2-event)	Chemical-specific
K_p	Dermal permeability coefficient of compound in water (cm/hr)	Chemical-specific
$t_{event\text{-}mu\_adj}$	Age-adjusted dermal exposure time per event, mutagens, resident (hr/event)	See Equation 35
t*	Time to reach steady state (hr)	2.4 x τ_{event}
FA	Fraction absorbed water (unitless)	Chemical-specific
τ_{event}	Lag time per event (hr/event)	Chemical-specific
B	Ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless)	Chemical-specific
TR	Target risk	1E-05
AT_r	Averaging time, resident, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
DFW_{mu_adj}	Age-adjusted dermal tap water exposure factor, mutagens, resident (cm^2-event /kg)	See Equation 36

Equation 35
Calculation of Age-Adjusted Tap Water Dermal Exposure Time per Event, Mutagens Residential Scenario

$$t_{event\_mu\_adj} = \frac{t_{event_{0-2}} \times ED_{0-2} + t_{event_{2-6}} \times ED_{2-6} + t_{event_{6-16}} \times ED_{6-16} + t_{event_{16-26}} \times ED_{16-26}}{ED_{0-2} + ED_{2-6} + ED_{6-16} + ED_{16-26}}$$

Parameter	Definition (units)	Default
$t_{event\_mu\_adj}$	Age-adjusted dermal exposure time per event, mutagens, tap water, resident (hr/event)	0.671
$t_{event\_0\text{-}2}$	Dermal exposure time per event, tap water, resident 0-2 years (hr/event)	0.54
$ED_{0\text{-}2}$	Exposure duration, resident 0-2 years (yr)	2
$t_{event\_2\text{-}6}$	Dermal exposure time per event, tap water, resident 2-6 years (hr/event)	0.54
$ED_{2\text{-}6}$	Exposure duration, resident 2-6 years (yr)	4
$t_{event\_6\text{-}16}$	Dermal exposure time per event, tap water, resident 6-16 years (hr/event)	0.71
$ED_{6\text{-}16}$	Exposure duration, resident 6-16 years (yr)	10
$t_{event\_16\text{-}26}$	Dermal exposure time per event, tap water, resident 16-26 years (hr/event)	0.71
$ED_{16\text{-}26}$	Exposure duration, resident 16-26 years (yr)	10

Equation 36
Calculation of Age-Adjusted Tap Water Dermal Exposure Factor, Mutagens

$$DFW_{mu\_adj} = \left[\frac{EF \times EV_{0-2} \times ED_{0-2} \times SA_c \times 10}{BW_c}\right] + \left[\frac{EF \times EV_{2-6} \times ED_{2-6} \times SA_c \times 3}{BW_c}\right] + \left[\frac{EF \times EV_{6-16} \times ED_{6-16} \times SA_a \times 3}{BW_a}\right] + \left[\frac{EF \times EV_{16-30} \times ED_{16-26} \times SA_a \times 1}{BW_a}\right]$$

Parameter	Definition (units)	Default
DFW_{mu_adj}	Age-adjusted tap water dermal exposure factor, mutagens, resident (cm^2-event /kg)	8,191,633
$EV_{0\text{-}2}$	Event frequency, resident 0-2 years (events/day)	1
$ED_{0\text{-}2}$	Exposure duration, resident 0-2 years (yr)	2
SA_c	Skin surface area available for contact, child (cm^2)	6,365
$EV_{2\text{-}6}$	Event frequency, resident 2-6 years (events/day)	1
$ED_{2\text{-}6}$	Exposure duration, resident 2-6 years (yr)	4
$EV_{6\text{-}16}$	Event frequency, resident 6-16 years (events/day)	1
$ED_{6\text{-}16}$	Exposure duration, resident 6-16 years (yr)	10
EF	Event frequency (days/yr)	350
SA_a	Skin surface area available for contact, adult (cm^2)	19,652
$EV_{16\text{-}26}$	Event frequency, resident 16-26 yr (events/day)	1
$ED_{16\text{-}26}$	Exposure duration, resident 16-26 (yr)	10
BW_c	Body weight, child (kg)	15
BW_a	Body weight, adult (kg)	80

Equation 37
Combined Exposures to TCE in Tap Water
Residential Exposure

$$C_{TCE-oral} = \frac{TR \times AT_r \times 1000}{CSF_o \times \left(\left(CAF_o \times IFW_{adj}\right) + \left(MAF_o \times IFWM_{adj}\right)\right)}$$

$$C_{TCE-derm} = See\ Equation\ 37$$

$$C_{TCE-inh} = \frac{TR \times AT_r}{\left(ET_{rs} \times K \times IUR\right) \times \left[\left(EF_r \times ED_{rs} \times CAF_i\right) + AgeTerms\right]}$$

$$Age\ Terms = \left(\left(\left[\left(ED_{0-2} \times EF_{r\times} \times MAF_i \times 10\right) + \left(ED_{2-6} \times EF_{r\times} \times MAF_i \times 3\right) + \left(ED_{6-16} \times EF_{r\times} \times MAF_i \times 3\right) + \left(ED_{16-26} \times EF_{r\times} \times MAF_i \times 1\right)\right]\right)\right)$$

Combined Exposures:

$$SL_{tap-TCE} = \frac{1}{\frac{1}{C_{TCE-oral}} + \frac{1}{C_{TCE-inh}} + \frac{1}{C_{TCE-derm}}}$$

Parameter	Definition (units)	Default
$C_{TCE-oral}$	Contaminant concentration, ingestion (µg/L)	Chemical-specific
$C_{TCE-derm}$	Contaminant concentration, dermal (µg/L) (See Equations 38-40)	Chemical-specific
$C_{TCE-inh}$	Contaminant concentration, inhalation (µg/L)	Chemical-specific
$SL_{tap-TCE}$	Tap water screening level (µg/L)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
CAF_o	Adjusted oral cancer slope factor (µg/m^3)$^{-1}$	See Equation 14
IFW_{adj}	Age-adjusted ingestion oral ingestion factor (L/kg)	See Equation 24
MAF_o	Age-adjusted mutagenic slope factor (µg/m^3)$^{-1}$	See Equation 14
$IFWM_{adj}$	Age-adjusted water ingestion rate, mutagens (L/kg)	See Equation 33
EF_r	Exposure frequency, resident (day/yr)	350
ET_{rw}	Exposure time (24 hr/day per 1day/24 hr)	1
K	Andelman volatilization factor (L/m^3)	0.5
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific
CAF_i	Adjusted inhalation cancer unit risk (µg/m^3)$^{-1}$	See Equation 16
MAF_i	Adjusted inhalation mutagenic unit risk (µg/m^3)$^{-1}$	See Equation 16
1000	Conversion factor (µg/mg)	1000
ED_{0-2}	Exposure duration, child (yr)	2
ED_{2-6}	Exposure duration, child (yr)	4
ED_{6-16}	Exposure duration, adult (yr)	10
ED_{16-26}	Exposure duration, adult (yr)	10

Equation 38
Dermal Exposure to TCE in Tap Water
Residential Scenario

If $t_{event\_adj} \leq t^*$, then:

$$C_{TCE-derm} = \frac{DA_{event\_TCE} \times 1000\ (cm^3/L)}{2 \times FA \times K_p \times \sqrt{\frac{6\tau_{event} \times t_{event\_mu\_adj}}{\pi}}}$$

If $t_{event\_adj} > t^*$, then:

$$C_{TCE-derm} = \frac{DA_{event\_TCE} \times 1000\ (cm^3/L)}{FA \times K_p \times \left[\frac{t_{event\_mu\_adj}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event\_TCE} = \frac{TR \times AT_r \times 1000(\mu g/mg)}{\left(\frac{CSF_o}{GIABS}\right) \times \left(\left(CAF_o \times DFW_{adj}\right) + \left(MAF_o \times DFWM_{adj}\right)\right)}$$

Parameter	Definition (units)	Default
$C_{mu\text{-}derm}$	Contaminant concentration, mutagens, dermal (µg/L)	Chemical-specific
DA_{event_mu}	Absorbed dose per event, mutagens (µg/cm^2-event)	Chemical-specific
K_p	Dermal permeability coefficient of compound in water (cm/hr)	Chemical-specific
$t_{event\ \_adj}$	Age-adjusted dermal exposure time per event, resident (hr/event)	See Equation 26
t*	Time to reach steady state (hr)	2.4 x τ_{event}
$t_{event\ \_mu\_adj}$	Age-adjusted dermal exposure time per event, mutagens, resident (hr/event)	See Equation 35
FA	Fraction absorbed water (unitless)	Chemical-specific
τ_{event}	Lag time per event (hr/event)	Chemical-specific
B	Ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless)	Chemical-specific
TR	Target risk	1E-05
AT_r	Averaging time, resident, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
CAF_o	Adjusted oral cancer slope factor	See Equation 14
MAF_o	Adjusted oral mutagenic slope factor	See Equation 14
DFW_{adj}	Age-adjusted dermal tap water exposure factor, resident (cm^2-event /kg)	See Equation 27
$DFWM_{adj}$	Age-adjusted dermal tap water exposure factor, mutagens, resident (cm^2-event /kg)	See Equation 36

2.5 Vapor Intrusion Screening Levels

Residential receptors and commercial/industrial workers could be exposed to volatile compounds vaporized from subsurface media (soil gas and/or groundwater) through pore spaces in the vadose zone and building foundations (or slabs) into indoor air. Per US EPA guidance (US EPA, 2002c), this pathway must be evaluated if: 1) there are compounds present in subsurface media

that are sufficiently volatile and toxic, and 2) there are existing or planned buildings where exposure could occur. A chemical is considered to be sufficiently volatile if its Henry's law constant is 1 x 10^{-5} atm-m^3/mole or greater and its molecular weight is approximately 200 g/mole or less. A chemical is considered to be sufficiently toxic if the vapor concentration of the pure component poses an incremental lifetime cancer risk greater than 1E-05 or the noncancer hazard index is greater than 1.0. VISLs were calculated for chemicals which are sufficiently volatile and toxic for evaluation of the vapor intrusion pathway following the guidance in the VISL User's Guide (US EPA, 2014b) and NMED-specific input parameters and are summarized in Table A-4. The list of chemicals included in Table A-4 is not comprehensive of all potential volatile and toxic compounds that may be present in site media. If volatile and toxic constituents are detected in site media and are not listed in Table A-4, VISLs should be calculated following the methodologies herein and risks addressed.

The US EPA (2002c) vapor intrusion guidance does not support the use of bulk soil data for evaluation of the vapor intrusion pathway; active soil gas and/or groundwater data must be used as appropriate. As such, VISLs are neither available nor recommended for soil. It is noted; however, that bulk soil data can be used in a qualitative sense to determine delineation of a vapor source or in determining if soil has been impacted and additional evaluation (e.g., soil gas) is needed. Conversely, it must not be assumed that non-detect results of volatile compounds in soil equates to an absence of a vapor source.

The NMED VISLs should be used as a first-tier screening assessment. However, if site concentrations exceed the VISLs, it is recommended that the assumptions underlying the NMED VISL calculations be reviewed and a determination made as to whether they are applicable at each site. Site-specific factors may result in unattenuated or enhanced transport of vapors towards a receptor, and consequently are likely to render the VISLs target subsurface concentrations overly or underly conservative.

Application of the VISLs is appropriate as a first-tier screening assessment for all sites except those where the following conditions apply. If any of the below are applicable to a site, a site-specific evaluation must be conducted:

- Very shallow groundwater sources [e.g., depth to water is less than five (5) ft below foundation level];
- Shallow soil contamination resulting in vapor sources (e.g., VOCs are found at significant levels within 10 ft of the base of the foundation);
- Buildings with significant openings to the subsurface (e.g., sumps, unlined crawlspaces, earthen floors) or significant preferential pathways, either naturally occurring or anthropogenic (not including typical utility perforations present in most buildings);
- Vapor sources originating in landfills where methane is generated in sufficient quantities to induce advective transport into the vadose zone;
- Vapor sources originating in commercial or industrial settings where vapor-forming chemicals can be released within an enclosed space and the vapor density of a chemical

may result in significant advective transport of the vapors downward through cracks and openings in floors and into the vadose zone; and/or

- Leaking vapors from gas transmission lines.

It is emphasized that the NMED VISLs are not meant to be used as action standards or cleanup levels. Rather, they should be used as a tool to estimate potential cumulative risks and/or hazards from exposure to volatile and toxic chemicals at a site where the underlying assumptions are deemed appropriate and if further evaluation is required (See Section 2.5.2, Evaluation of the Vapor Intrusion Pathway and Section 6.4, TPH VISLs).

2.5.1 Calculation of Vapor Intrusion Screening Levels

NMED VISLs were calculated per US EPA (2002c, 2009, and 2015c) methods and guidance. A risk-based target indoor air concentration was used as a basis for back-calculating an allowable amount of a contaminant in soil-gas and/or groundwater assuming a certain amount of attenuation and dilution through the vadose zone and into the building.

Attenuation is the reduction in concentrations that occurs through migration in the subsurface combined with the dilution that occurs when vapor enters a building and mix with indoor air. The attenuation factor is expressed as the ratio of concentrations of chemicals in indoor air to the concentrations in subsurface vapor. Although attenuation factors are site specific and can vary depending on several variables (e.g., soil type, depth of contamination, building characteristics and indoor air exchange rates), NMED VISLs were calculated utilizing US EPA default attenuation factors which are based on conservative assumptions and empirical data. As recommended by US EPA (2015a), a default attenuation factor of 0.03 was applied to establish soil-gas VISLs, and a default attenuation factor of 0.001 was applied in establishing groundwater VISLs. Soil-gas VISLs were calculated by dividing the risk-based target indoor air concentration by the default attenuation factor, as shown in Equation 39. Equation 40 also shows that groundwater VISLs were calculated by dividing the risk-based target indoor air concentration by the default attenuation factor and converting the vapor phase concentration to a groundwater concentration utilizing a conversion factor and Henry's Law Constants to estimate partitioning between the aqueous phase and vapor phase, assuming equilibrium between the two phases.

Equation 39
Calculation of Vapor Intrusion Screening Levels

$$VISL_{sg} = \frac{C_{indoor}}{\alpha}$$

$$VISL_{gw} = \frac{C_{indoor}}{HLC \times \alpha \times 1000L/m^3}$$

Parameter	Definition (units)	Default
$VISL_{sg}$	Vapor intrusion screening level for soil-gas (µg/m^3)	Chemical and receptor-specific
$VISL_{gw}$	Vapor intrusion screening level for groundwater (µg/L)	Chemical and receptor-specific
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical and receptor-specific
α	Attenuation coefficient (unitless)	0.03 (soil-gas) 0.001 (groundwater)
HLC	Henry's Law Constant at standard temperature of 25 C (unitless)	Chemical-specific

The NMED groundwater VISLs were calculated based on a default standard temperature of 25 degrees Celsius (C). Although groundwater temperatures at many sites in New Mexico would likely be lower than 25 degrees C, this default value was selected to be protective of all sites in New Mexico.

The risk-based target indoor air concentrations were calculated using US EPA (2009, 2015c, and 2014a) algorithms, current toxicity data, and exposure factors used in the evaluation of other exposure pathways outlined in this document. Equations 40 through 43 present the formulas and exposure parameters used for calculating risk-based target indoor air concentrations for residential receptors. Separate indoor air concentrations were calculated for carcinogenic and noncarcinogenic contaminants, and alternate methods were utilized for vinyl chloride and other compounds that are carcinogenic via a mutagenic mode of action. Equations 44 through 56 present the formulas and exposure parameters used for calculating carcinogenic and noncarcinogenic target indoor air concentrations for the commercial/industrial scenario. Target indoor air concentrations for ecological receptors and the construction worker scenario were not calculated as the vapor intrusion exposure pathway is typically incomplete for receptors that spend their time outdoors. Under unique circumstances, such as work being conducted in a trench or other low-lying areas where vapors could accumulate, special assessment of the vapor intrusion pathway may be required for the construction worker. The need for evaluation of the construction worker will be made on a case-by-case basis.

Equation 40
Calculation of Target Indoor Air Concentrations – Carcinogens
Residential Scenario

$$C_{indoor} = \frac{TR \times AT_c}{EF \times ED \times ET \times IUR}$$

Parameter	Definition (units)	Default
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical-specific
TR	Target risk level	1E-05
AT_c	Averaging time for carcinogens (days)	25,550
EF	Exposure frequency (days)	350
ED	Exposure duration (yr)	26
ET	Exposure time (24 hr/day x 1 day/24 hr)	1
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific

Equation 41
Calculation of Target Indoor Air Concentrations – Noncarcinogens
Residential Scenario

$$C_{indoor} = \frac{THQ \times AT_{nc} \times 1000 \mu g/mg}{EF \times ED \times ET \times \left(\frac{1}{RfC}\right)}$$

Parameter	Definition (units)	Default
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical-specific
THQ	Target hazard quotient	1
AT_{nc}	Averaging time for noncarcinogens (days)	ED x 365
EF	Exposure frequency (days)	350
ED	Exposure duration (yr)	26
ET	Exposure time (24 hr/day x 1 day/24 hr)	1
RfC	Inhalation reference concentration (mg/m^3)	Chemical-specific

Equation 42
Calculation of Target Indoor Air Concentrations – Vinyl Chloride
Residential Scenario

$$C_{indoor} = \frac{TR}{IUR + \left(\frac{EF \times ED \times ET \times IUR}{AT_c}\right)}$$

Parameter	Definition (units)	Default
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical-specific
TR	Target risk level	1E-05
AT_c	Averaging time for carcinogens (days)	25,550
EF	Exposure frequency (days)	350
ED	Exposure duration (yr)	26
ET	Exposure time (24 hr/day x 1 day/24 hr)	1
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific

Equation 43
Calculation of Target Indoor Air Concentrations – Mutagens
Residential Scenario

$$C_{indoor} = \frac{TR \times AT_c}{EF \times ET \times [(ED_{0-2} \times IUR \times 10) + (ED_{2-6} \times IUR \times 3) + (ED_{6-16} \times IUR \times 3) + (ED_{16-26} \times IUR \times 1)]}$$

Parameter	Definition (units)	Default
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical-specific
TR	Target risk level	1E-05
AT_c	Averaging time for carcinogens (days)	25,550
EF	Exposure frequency (days)	350
$ED_{0\text{-}2}$	Exposure duration (0-2 yr)	2
$ED_{2\text{-}6}$	Exposure duration (2-6 yr)	4
$ED_{6\text{-}16}$	Exposure duration (6-16 yr)	10
$ED_{16\text{-}26}$	Exposure duration (16-26 yr)	10
ET	Exposure time (24 hr/day x 1 day/24 hr)	1
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific

Equation 44
Calculation of Target Indoor Air Concentrations – Carcinogens
Commercial/Industrial Scenario

$$C_{indoor} = \frac{TR \times AT_c}{EF \times ED \times ET \times IUR}$$

Parameter	Definition (units)	Default
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical-specific
TR	Target risk level	1E-05
AT_c	Averaging time for carcinogens (days)	25,550
EF	Exposure frequency (days)	225
ED	Exposure duration (yr)	25
ET	Exposure time (8 hr/day x 1 day/24 hr)	0.33
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific

Equation 45
Calculation of Target Indoor Air Concentrations – Noncarcinogens
Commercial/Industrial Scenario

$$C_{indoor} = \frac{THQ \times AT \times 1000 \mu g/mg}{EF \times ED \times ET \times \left(\frac{1}{RfC}\right)}$$

Parameter	Definition (units)	Default
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical-specific
THQ	Target hazard quotient	1
AT	Averaging time for noncarcinogens (days)	ED x 365
EF	Exposure frequency (days)	225
ED	Exposure duration (yr)	25
ET	Exposure time (8 hr/day x 1 day/24 hr)	0.33
RfC	Inhalation reference concentration (mg/m^3)	Chemical-specific

2.5.2 Evaluation of the Vapor Intrusion Pathway

During the investigation phase, if VOCs are detected in soil and/or site history indicates the potential for VOCs in site media, soil gas samples and groundwater sampling are likely to be required. The need for collection of soil gas data will be made on a case-by-case basis with input from NMED.

The assessment of the soil gas and groundwater data should include evaluation of the vapor intrusion pathway. Two types of soil gas data are collected: passive and active. Passive soil gas results are used for nature and extent purposes only; to determine the absence or presence of VOCs. Active soil gas data are required for quantitative risk assessments.

Chemicals that should be considered for the vapor intrusion pathway include those with a Henry's law constant of approximately 1 x 10^{-5} atm-m^3/mole or greater, a molecular weight of approximately 200 g/mole or less and known to pose a potential cancer risk or noncancer hazard through the inhalation pathway. If all three of these criteria are met, the constituent is considered volatile and toxic. Table A-4 contains the VISLs for chemicals which met these three criteria. However, this list in Table A-4 is <u>not</u> comprehensive and any additional compounds meeting the above three criteria not listed in Table A-4 and present in site media will require additional analyses following the methods contained herein.

The US EPA no longer recommends use of bulk soil (as opposed to soil gas) data for a qualitative estimate of the potential for vapor intrusion to pose unacceptable human health risk in indoor air, as was done using the Johnson and Ettinger (J&E) model (US EPA 2015). This is due to the potential for vapor loss due to volatilization during soil sampling, preservation, and chemical analysis. In addition, there are uncertainties associated with soil partitioning calculations. As such, use of bulk soil J&E results is not recommended or preferred as a line of evidence to support an evaluation of the vapor intrusion pathway. In lieu of using results from the J&E bulk soil model, the lines of evidence approach outlined in Sections 2.5.2.1 through 2.5.2.3 should be followed.

For each site investigation conducted in New Mexico, one of the following three designations shall be made for the vapor intrusion pathway: 1) incomplete pathway and no action required; 2) potentially complete pathway and a qualitative evaluation required; or 3) complete pathway and quantitative evaluation required.

2.5.2.1 Incomplete Pathway; No Action Required

The vapor-intrusion pathway is designated as "incomplete" and will not be evaluated further if one of the following conditions is met:

(1) There are no buildings located near the site and buildings are reasonably expected to be absent in the future (US EPA, 2015a).

(2) Volatile and toxic compounds are not detected, meaning all the results were 100% nondetects.

(3) The site has no history of containing volatile and toxic compounds and VOC sampling was not conducted during the investigation.

US EPA recommends that any determination that the vapor intrusion pathway is incomplete be supported by site-specific evidence to demonstrate that the nature and extent of vapor-forming chemical contamination in the subsurface has been well characterized and the types of vapor sources and the conditions of the vadose zone and surrounding infrastructure do not present opportunities for unattenuated or enhanced transport of vapors toward and into any building. This site-specific evidence must be provided in the risk assessment.

2.5.2.2 Potentially Complete Pathway; Qualitative Discussion

If all the following criteria are met during investigation sampling, the pathway is considered potentially complete and a qualitative discussion of the vapor intrusion pathway will be required:

- Detections of volatile and toxic compounds are minimally detected (e.g., once or twice) in site media (soil, soil gas, and/or groundwater);
- Concentrations are below screening levels (i.e., VISLs for soil-gas and/or groundwater Table A-4);
- There is no suspected source(s) for volatile and toxic compounds; and
- Concentrations are decreasing with depth (for soil).

In addition, if volatile and toxic compounds were present at a site but the source(s) and associated contaminated soil have been removed and the following criteria have been met, only a qualitative assessment of the vapor intrusion pathway will be required:

- Confirmation sampling indicates removal of the source with minimal volatile and toxic compounds detected in soil/soil gas or groundwater data,

- Concentrations are below screening levels (i.e., VISLs for soil-gas and/or groundwater; Table A-4),
- No evidence to suggest dense/sinking vapors, and
- Concentrations decrease with depth.

2.5.2.3 Complete Pathway; Quantitative Assessment

If volatile and toxic compounds are detected consistently in site media during investigation or confirmation sampling, concentrations are detected at depth or show increasing concentrations with depth in soil, and/or there is potentially a source(s) for the volatile and toxic compounds based on site history, a quantitative assessment of the vapor intrusion pathway is required following a tiered approach, until the conditions of a given step are met.

Step 1. Compare the maximum detected concentration for soil gas or groundwater against the NMED VISLs. If active soil gas data are collected from soils located outside of a structure or below a slab, the VISL target sub slab and exterior soil gas concentrations for a target cancer risk of 1E-05 and a target hazard quotient of 1.0 should be applied. The VISL target groundwater concentrations for a target cancer risk of 1E-05 and a target hazard quotient of 1.0 should be applied for groundwater data. It is important to note that cumulative risk and hazard estimates from the vapor intrusion pathway must be added to the cumulative risk and hazard from other exposures at the site (e.g., soil and tap water exposure pathways) per Equations 58 and 59. The NMED VISLs may be modified using additional site-specific data and as approved by NMED. If the risks/hazards are acceptable, no additional evaluation is needed; otherwise, proceed to Step 2.

However, the comparison of sample concentrations to the VISLs is only one line of evidence to assess risk at a site. The single-chemical VISLs do not account for the cumulative effect of all vapor-forming chemicals that may be present. Thus, if multiple chemicals are present, a health threat may exist at a specific building or site even if none of the individual substances exceeds its VISL. The resulting cancer/noncancer risks calculated using the VISLs must be added to other site risks, per Equations 58 and 59 in Section 5.0.

Step 2. Per the US EPA vapor intrusion guidance (US EPA, 2015), if initial screening using VISLs results in excess risk, US EPA recommends considering whether the assumptions underlying the generic conceptual model are attained at a given site. If they are not attained, then the medium-specific VISLs should not be relied upon as a line of evidence for identifying sites or buildings unlikely to pose a health concern through the vapor intrusion pathway. If the screening analyses following the approach in Step 1 results in excess risk/hazard, the following should be conducted.

Evaluation of the vapor intrusion pathway should be based on multiple lines of evidence developed to support a refined and technically defensible CSM and a thorough characterization of potential subsurface vapor sources. This can be accomplished by gathering and interpreting information on:

- Subsurface vapor sources. This should include a thorough review of the site history and identification of potential subsurface vapor sources. This information should be accompanied by media specific data to confirm the presence of a vapor source at the site. The media-specific data should reflect spatial and temporal variations. Groundwater and soil gas concentrations should be compared to NMED VISLs to evaluate source strength and the potential for impacts to human health, if the vapor intrusion pathway is complete.
- Vapor migration and attenuation in the vadose zone. This should include soil gas data that represents spatial and vertical variations in soil gas concentrations, information on site geology and hydrogeology, and identification of any preferential pathways (e.g., utility conduits in the subsurface) for chemical vapors between the source and building.
- The building foundation. This should include information on construction materials, preferential pathways (i.e., openings) in the foundation, heating/cooling/ventilation system characteristics, photoionization detector readings at potential openings to the subsurface, grab samples of indoor air close to potential vapor entry points, and information on building pressure gradients.
- The building interior. This should include coinciding subslab soil gas and indoor air measurements, results of site-specific transport modeling, and comparisons of subslab soil gas and indoor air sampling results to determine site-specific attenuation factors.
- Sources of VOCs within the building and in ambient air. Information is needed to identify sources of VOCs inside and outside of the building that could potentially impact indoor air concentrations of VOCs. Note that outdoor air samples should be taken in conjunction with coinciding subslab soil gas and indoor air samples are collected.
- Additional lines of evidence, such as statistical analysis of the gathered data.

The collected lines of evidence should be assessed for concordance. If concordance can be reached, decisions regarding the vapor intrusion pathway can be made with confidence. However, some lines of evidence may not be definitive. Indoor air and subsurface soil gas concentrations can vary greatly both temporally and spatially. Some individual lines of evidence may be inconsistent with other lines of evidence and lead to the need for additional evaluation. If concordance among the lines of evidence cannot be determined, the evaluation of the vapor intrusion pathway should move to Step 3.

Step 3: When lines of evidence are not concordant, and the weight of evidence does not support a confident decision, additional sampling or collecting additional lines of evidence may be appropriate, depending upon the CSM.

Step 4: If it is determined that vapor intrusion can potentially impact human health, NMED generally recommends that a human health risk assessment be conducted to determine whether the potential for human health risks posed to building occupants is within or

exceeds acceptable NMED levels. The risk posed to building occupants by vapor intrusion depends upon chemical toxicity, vapor concentration in indoor air, the amount of time the occupants spend in the building, and other variables. NMED recommends that risk assessment guidance be used to identify, develop, and combine information about these variables to characterize health risks stemming from vapor intrusion from subsurface vapor sources.

2.6 Beef Ingestion Soil Screening Levels

For those sites greater than two acres in size, grazing of cattle must be evaluated to determine if beef ingestion is a plausible and complete exposure pathway. If grazing is not permitted (or could not be permitted due to land use restrictions), or the land does not support grazing (e.g., insufficient forage and/or water availability, terrain, or highly industrialized area), lines of evidence must be provided to demonstrate this as an incomplete pathway.

If grazing is viable or if a facility may potentially allow grazing on lands at some time in the future, a qualitative assessment of ingestion of beef from cattle grazing on potentially contaminated sites is required. While preliminary remediation goals (PRGs) are available from the Risk Assessment Information System (RAIS) on-line tool, the model has not been updated to reflect current risk assessment input parameters or methodology. As such, the beef ingestion pathway can be addressed in a qualitative assessment in the Uncertainties Section of the risk assessment, providing multiple lines of evidence to characterize potential risks. Acceptable lines of evidence may include the following:

- Percent of acreage impacted by site contamination is less than two acres in size resulting in only a fraction of the cow's diet (grass only, forage, silage, grain) being potentially contaminated;
- Levels of contamination are below residential screening levels;
- No significant ecological risks for the larger game receptors; and
- Beef ingestion rates (or percentage of beef in diets) for the potential receptors for the region/area.

2.7 Site Characterization

The site characterization phase is intended to provide l spatial and contextual information about the site, which may be used to determine if there is any reason to believe that receptors and/or complete exposure pathways may exist at or in the locality of the site where a release of hazardous waste/constituents has occurred. During site characterization, the data quality objectives are defined, and site sampling is conducted to define nature and extent of contamination. During the development of the site characterization work plan (e.g., RCRA Facility Investigation work plan), site history should be reviewed to determine preliminary COPCs that should be included in sampling, determine background threshold values (BTVs) and define a preliminary site conceptual exposure model (SCEM) to ensure all appropriate media are sampled.

Risk assessments are conducted once the nature and extent of contamination has been defined.

2.7.1 Development of Data Quality Objectives

Before any environmental samples are collected, data quality objectives (DQOs) should be developed. The DQOs should address the qualitative and quantitative nature of the sampling data, in terms of relative quality and intent for use, to ensure that any data collected will be appropriate for the intended purpose. Development of the DQOs should consider not only precision, accuracy, representativeness, completeness, and comparability of the data, but also the sampling locations, methods of sample collection, types of laboratory analyses used, sensitivity of detection limits of the analytical techniques, the resulting data quality, and the employment of adequate quality assurance/quality control measures.

2.7.2 Determination of Background Threshold Values

Site-specific BTVs should be established during a site-specific soil background study, using a methodology reviewed and approved by NMED. Sample size, locations, as well as other site-specific parameters for background data sets should be outlined during the DQO process presented in the associated study work plan. Guidance on the process of conducting a background soil study is beyond the scope of this document. However, the following criteria are representative of a defensible background data set:

- Includes enough data for statistical analyses;
- Free of statistically-determined outliers;
- Reliably representative of the variations in background media (e.g., soil types or groundwater horizons);
- Collected from areas where there is no potential for site contamination based on site history;
- Areas not impacted by neighboring areas of contamination (off-site migration);
- Collected from areas that are upwind of contaminated soil;
- Collected from areas that are upgradient of site contamination;
- Collected from soil types that are lithologically comparable to the samples that will be collected from contaminated areas; and
- Collected from depths that correspond to the exposure intervals that will be evaluated during human and ecological risk assessments.

An adequate sample size will likely capture a reliable representation of the background population while meeting the minimum sample size requirements for calculating BTVs and conducting hypothesis testing. US EPA (2015b) recommends 10 to 15 samples for each background data set, but more are preferable. While it is possible to calculate BTVs with small data sets containing as few as three samples, these results are not considered representative and reliable enough to make cleanup or remediation decisions. Therefore, a minimum sample size of 10 is required to calculate BTVs and conduct hypothesis testing. The size of the background

area and size of the site or facility under study should also be considered in determining sample size. That is, if the background and site areas are relatively large, then a larger background data set (e.g., > 10 samples) should be considered (US EPA, 2015b). Background soil data are often grouped according to depth (e.g., surface vs. subsurface) or soil type. It is important to note that the minimum sample size of 10 should be met for each grouping of data to compute BTVs for each soil horizon or soil type.

Determination of BTVs should be conducted using current ProUCL software and guidance. In general, BTVs should be based on 95% upper tolerance limits (UTLs) with 95% coverage. Exceptions can occur on a case-by-case basis when the estimated 95% UTL is significantly greater (more than 1.5 times) than the maximum detected concentration. This may be an indication that the 95% UTL is based on the accommodation of low-probability outliers (which may or may not be attributable to the background population) or highly skewed data sets and/or possibly inadequate sample size. In these cases, the project team may choose to evaluate the possibility of additional potential outliers or collection of more data. In lieu of collection of additional data to resolve the elevated UTL issue, the maximum detected concentration should be used as the BTV.

2.8 Site Assessment

Once nature and extent of contamination has been defined, the site assessment phase serves to determine potential exposures. The SCEM is refined to develop a CSM, providing a list of the exposed receptors and complete exposure pathways for further assessment (i.e., a screening level assessment). The data may also be used to assess whether interim measures are required or whether the site poses minimal threat to human and ecological receptors at or near the site.

The ultimate purpose of the site assessment phase is to address the question: Are exposure pathways complete regarding contaminant contact by receptors? A complete site assessment will consist of several steps:

- Develop a refined CSM;
- Determine exposure intervals;
- Identify preliminary COPCs; and
- Compare maximum COPC concentrations for consideration of complete exposure pathways with SSLs.

If the site maximums are above the SSLs, a Tier 2 approach may be deemed appropriate by NMED using the 95% UCL value for contaminant concentrations (or detection/quantitation limits for non-detect results).

2.8.1 Development of a Refined Conceptual Site Model

A CSM is a three-dimensional graphical representation of site conditions that conveys what is known or suspected, at a discrete point in time, about the site-specific sources, releases, release mechanisms, contaminant fate and transport, exposure routes, and potential receptors. The CSM

is generally documented by written descriptions and supported by maps, geological cross-sections, tables, diagrams and other illustrations to communicate site conditions. When preparing a CSM, the facility should decide the scope, quantity, and relevance of the information to be included, balancing the need to present as complete a picture as possible to document current site conditions and justify risk management actions, with the need to keep the information focused and exclude extraneous data.

As a final check, the CSM should answer the following questions:

- Are there potential land uses present (now or in the foreseeable future) other than those covered by the SSLs (refer to US EPA 1989)?
- Are there other likely human exposure pathways (e.g., vapor intrusion, direct exposure to groundwater, local fish consumption, raising homegrown produce, beef, dairy, or other livestock) that were not considered in development of the SSLs (refer to US EPA 1989)?
- Are there potential ecological concerns (*refer to Volume II of the SSG*)?

If any conditions such as these exist, the SSLs may need to be adjusted to reflect this new information.

2.8.2 Determine Exposure Intervals

Based on current and potential land-use scenarios, receptors for completed exposure pathways can be exposed to varying depths of soil, or soil exposure intervals. Per US EPA (US EPA 1989), depth of samples should be considered, and surface soils should be evaluated separately from subsurface soils due to possible differences in exposure levels that would be encountered by different receptors. Exposure intervals for each receptor are based on the types of activities in which each receptor is likely to be involved. Default exposure intervals are summarized in Table 2-6.

It is assumed that commercial/industrial workers would only be exposed to surface soils (0-1 feet bgs). As stated in Section 2.3.1, this receptor may be involved in moderate digging associated with routine maintenance and grounds keeping activities. Therefore, COPC concentrations in soil in the surface soil interval (0-1 feet bgs) should be considered when evaluating exposure by a commercial/industrial worker receptor.

As stated in Section 2.3.2, a construction worker is assumed to be exposed to surface and subsurface soils up to depths of 0-10 ft bgs. Construction workers are involved in digging, excavation, maintenance and building construction projects and could be exposed to surface as well as subsurface soil. Therefore, a soil exposure interval of 0-10 feet bgs should be considered when evaluating exposure to soil by a construction worker.

Residents could be exposed to surface and subsurface soils during home maintenance activities, yard work, landscaping, and outdoor play activities. Therefore, an exposure soil interval of 0-10 feet bgs should be assumed when evaluating soil exposure by a residential receptor.

Exposure to COPCs in soil by ecological receptors should be addressed separately in a tiered approach as outlined in Volume II of this document and by NMED (2014). However, a discussion of soil exposure intervals for ecological receptors is warranted here because ecological receptors are considered in the CSM and depending on the types of ecological receptors, there could be a differential in exposure levels due to soil exposure intervals. Burrowing animals would be exposed to deeper soils, whereas all other animals would only be exposed to surface and shallow subsurface soils. Therefore, maximum concentrations of COPCs in soil 0-6 feet bgs should be assessed for burrowing animals. Maximum COPC concentrations in soil 0-1 ft bgs should be assessed for all other animals.

Table 2-6. Soil Exposure Intervals

Receptor	Exposure Intervals (Soil)
Resident (adult and child)	0 – 10 ft bgs
Commercial/Industrial Worker	0 – 1 ft bgs
Construction Worker	0 – 10 ft bgs
Vapor Intrusion	Depth of maximum detection
Soil-to-Groundwater Migration	Depth of maximum detection
Ecological Receptors (non-burrowing)	0 – 1 ft bgs
Ecological Receptors (burrowing)	0 – 6 ft bgs

2.8.3 Identification of COPCs

COPCs are those substances (including transformation or breakdown compounds and companion products) likely to be present in environmental media affected by a release. Identification of COPCs should begin with existing knowledge of the process, product, or waste from which the release originated. For example, if facility operations deal primarily with pesticide manufacturing then pesticides should be considered COPCs. Contaminants identified during current or previous site investigation activities should also be evaluated as COPCs. A site-specific COPC list for soil may be generated based on maximum detected (or, if deemed appropriate by NMED, the 95% UCL value) concentrations (US EPA 2002b) and a comparison of detection/quantitation limits for non-detect results to the NMED SSLs. This list may be refined through a site-specific risk assessment.

For the initial screening assessment, duplicates should be handled using the higher concentration as the EPC; averaging of the data is not appropriate for the initial screening assessment. If a refined EPC is needed, the original sample result should be applied.

2.8.3.1 Organics and Chemicals without Background Data

Per US EPA guidance (US EPA 1989), if there is site history to indicate a chemical was potentially used/present at a site or if there is insufficient site history to demonstrate that a chemical could not be present, and the chemical was detected in at least one sample, this chemical must be included as a COPC and evaluated in the screening assessment. Frequency of detection or other lines of evidence may not be used to eliminate a chemical as a COPC if there is history to indicate it is potentially present due to site activities; although these lines of evidence may be addressed in the uncertainty analysis for the risk assessment.

It is possible a site may have been impacted by other anthropogenic sources. As one line of evidence to help assess site impact to certain organics, development of baseline levels for organics may be appropriate. For example, PAHs may be present due to runoff from nearby paved/industrial structures, and dioxins/furans may be ubiquitous due to natural fires. If there are other potential sources of organics, the site characterization work plan should include sampling to determine baseline organic levels. In lieu of baseline sampling, additional lines of evidence may be required to justify the organics as not being site related. Factors to consider are proximity to other source areas for contamination (e.g., paved roads), magnitude of detection,

spatial variability.

2.8.3.2 Organics and Chemicals with Background Data

For organics and inorganics where background data are available, a comparison of site concentrations to appropriate background concentrations may be conducted prior to evaluation against SSLs. Those organics and inorganics that are present at levels indicative of natural background may be eliminated as COPCs and not carried forward to the screening assessment calculations. Comparison to background must be conducted following current US EPA Guidance and as outlined herein. The general process is a tiered approach.

2.8.3.2.1 Discrete Samples

For discrete data, the following tiered approach should be applied for determining if site data are reflective of background conditions.

Step 1. Compare the maximum detected site concentration to the site-specific background reference values (upper tolerance limit or upper threshold value) determined for each soil type and soil depth at the site. If the site maximum is less than the background reference value, it is assumed that the site concentrations are representative of background and the metal/inorganic/organic is not retained as a COPC. If there is no background value for a constituent, then the constituent must be retained as a COPC.

Step 2: If the maximum site concentration is greater than the background reference value, then a two-sample hypothesis test should be used to compare the distributions of the site data to the distributions of background data to determine if site concentrations are elevated compared with background. A simple comparison to the range of background is not acceptable. Background can vary across a site (especially larger sites) and not allow for soil type to be taken into consideration. Further, a range can mask low level contamination. **Comparisons of site data to the range of background values or comparison to the maximum detected concentration in the background data set cannot be used as a line of evidence to eliminate site constituents as COPCs.**

The most recent version of US EPA's ProUCL statistical software will be used for hypothesis testing. ProUCL will also be used to determine the most appropriate test (parametric or nonparametric) based on the distribution of the data. Appropriate methods in ProUCL will also be used to compute site-to-background comparisons based on censored data sets containing non-detect values. A review of graphical displays (e.g., box plots and Q-Q plots) may also be provided in addition to the results of the statistical tests to provide further justification in determining whether site concentrations are elevated compared with background. These graphical plots can also be generated by ProUCL software.

Note that the above two-sample test can only be used for site data sets that have sufficient samples (i.e., $n \geq 8$) and number of detections (greater than 5 detected

observations is preferred). While a minimum of 10 background data samples are now required, there may be sites where background has been previously determined from a data set that contains fewer than 10 samples. As stated in the current version of ProUCL User's Guide (US EPA, 2015b), hypothesis testing is only considered to be reliable with sufficient sample size ($n \geq 8$) and frequency of detection. If there are not at least eight samples in the site data set and at least five detections, then the site maximum detected concentrations will be compared to the corresponding background value (i.e., 95% upper tolerance limit) as noted in Step 1 or additional data must be collected to conduct a two-tailed test.

Step 3: Additional lines of evidence may be used to justify exclusion of a constituent as being site related, such as site history, high percentage of non-detects, etc. However, these lines of evidence must be based on a sufficient number of samples to adequately define nature and extent and to clearly delineate potential hotspots. For areas where a hotspot may be present, additional actions are required (such as sampling and/or corrective actions) and the constituent(s) must be retained as a COPC. Comparison of site data to regional data [such as US Geological Survey (USGS) databases not specific to the site] and simple comparison to a range of data or quartiles are not acceptable lines of evidence.

2.8.3.2.2 Incremental Site Methodology (ISM) Data

If ISM data are to be collected, a similar process as above comparing site data to background may be conducted. However, the ISM BTVs must also be derived using the ISM approach. **ISM data may not be compared to BTVs based on discrete sampling.** ProUCL is being updated to include hypothesis testing and calculation of statistically derived upper thresholds for ISM data. However, until such statistical evaluations are available in ProUCL, the following approach should be conducted for comparing site ISM to background ISM data:

- If the site ISM maximum detected concentration is less than the background minimum ISM, the constituent may be considered present at ambient concentrations and does not require retention as a COPC.
- If the site ISM maximum falls within the range of background ISM, a qualitative discussion and lines of evidence must be provided to justify exclusion of the constituent as a COPC. Evaluation of triplicate data should be included.
- If the site ISM maximum is greater than the background ISM minimum, the constituent must be retained as a COPC.

2.8.4 Initial and Refined Exposure Point Concentrations

For the initial evaluation, the maximum detected concentration shall be used as the EPC. If it is determined that further assessment is warranted (see Section 5), refinement of EPCs should be conducted. US EPA (1989) recommends using a concentration to represent "a reasonable estimate of the concentration likely to be contacted over time". US EPA's (1992b) *Supplemental Guidance to RAGS: Calculating the Concentration Term* states that, "because of the uncertainty associated with estimating the true average concentration at a site, the 95 percent upper

confidence limit (UCL) of the arithmetic mean should be used for this variable."

2.8.4.1 Discrete Data

Upper confidence limits should only be calculated for data sets that meet the US EPA (2015b) minimum requirements for calculating UCLs. The minimum requirements for calculating UCLs are: 1) each data set must contain at least eight samples (i.e., $n \geq 8$) for the analyte being evaluated; and 2) there must be a minimum of five detections (i.e., ≥ 5 detected observations) for the analyte being evaluated. Although it is possible to calculate UCLs with small datasets (i.e., $n \leq 8$) and low frequencies of detection (i.e., < 5 detected observations), these estimates are not considered reliable and representative enough to make defensible and correct cleanup and remediation decisions (US EPA, 2015b). Therefore, UCLs should only be calculated for data sets that meet the minimum requirements for calculation UCLs. For datasets with less than four detects or datasets with less than 10 samples and a low level of detection (less than 10%), the median concentration may be used as the EPC.

UCLs should be calculated using the most current version of US EPA's ProUCL statistical software package. Statistical methods for calculating UCLs are dependent on the distribution of the data. Therefore, when calculating UCLs, ProUCL should be used to perform statistical tests in order to determine the distribution of the site data. If assumptions about the distribution cannot be made, then nonparametric methods can be utilized. ProUCL recommends a computational method for calculation of the 95% UCL based on the assumed distribution.

Using parametric and nonparametric methods, ProUCL will typically return several possible values for the UCL. Professional judgment should be used in selecting the most appropriate UCL; however, the UCL recommended by ProUCL is based on the data distribution and is typically the most appropriate value to be adopted as the EPC for use in risk assessments. It is important to note that the UCL should not be greater than the maximum detected concentration.

Non-detects (censored datasets) should be evaluated following the appropriate methodology outlined in the most recent version of US EPA's ProUCL Technical Guide. Currently, the ProUCL Technical Guide indicates that the Kaplan-Meier (KM) method yields more precise and accurate estimate of decision characteristics than those based upon substitution and regression on order statistics. Use of one-half the minimum detection limit (MDL) or sample quantitation limit (SQL), or other simple substitution methods, are not considered appropriate methods for handling non-detects.

2.8.4.2 ISM Data

The Interstate Technology & Regulatory Council (ITRC) 2012 guidance states that "In theory, all of the UCL methods that are applied to discrete sampling results can also be applied to ISM. In practice, however, because fewer than eight replicate ISM samples are likely to be collected for a decision unit (DU), fewer options are typically available to calculate a UCL compared with discrete sampling data." For those DUs where there are eight or more sample units (SUs), the current version of US EPA's ProUCL should be used to calculate a UCL and the recommended UCL (if less than the maximum) used in the risk assessment. Triplicates should be

conservatively represented in the calculation of the UCL as the maximum of the detected results, which will bias the UCL high.

For those DUs where there are three (3) to eight (8) SUs, ITRC (2012) and US EPA (2015b) guidance indicate that not all of the UCL calculation methods provided in ProUCL are reliable. Instead, ITRC (2012) guidance indicates that either the Student's-t UCL or the Chebyshev UCL be used for DUs with 3-8 SUs. For these DUs (with 3-8 SUs), ProUCL should be run and the Student's t UCL used as the EPC if the data are determined to be normally distributed. If the data are determined to not be normally distributed, the 95% Chebyshev UCL should be used as the UCL. Triplicate data should be represented by the maximum of the detected values.

For DUs with 1-2 SUs, a UCL should not be calculated; the EPC should be the maximum detected concentration.

For chemicals with both non-detected results and detected results, the Kaplan-Meier based UCLs (using Student's-t or Chebyshev) should be used, as recommended by US EPA (2015b) guidance.

3.0 CHEMICAL-SPECIFIC AND PHYSICAL-CHEMICAL PARAMETERS

Chemical-specific parameters required for calculating SSLs include the organic carbon normalized soil-water partition coefficient for organic compounds (K_{oc}), the soil-water partition coefficient (K_d), water solubility (S), octanol-water partition coefficient (K_{ow}), Henry's Law constant (H), diffusivity in air (D_a), and diffusivity in water (D_w). The following sections describe these values and present methodologies for calculating additional values necessary for calculating the NMED SSLs.

3.1 Volatilization Factor for Soil

Volatile chemicals, defined as those chemicals having a Henry's Law constant greater than 1E-05 atm-m^3/mole and a molecular weight less than 200 g/mole, were screened for inhalation exposures using a volatilization factor (VF) for soils. The soil-to-air VF_s is used to define the relationship between the concentration of the contaminant in soil and the flux of the volatilized contaminant to ambient air. The emission terms used in the VF are chemical-specific and were calculated from physical-chemical information obtained from several sources including: US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA, 1996a), *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a), US EPA Master Physical and Chemical Parameter table for development of US EPA Regional Screening Levels (refer to US EPA 2016a), US EPA's *Basics of Pump and Treat Groundwater Remediation Technology* (US EPA 1990), US EPA's *Dermal Exposure Assessment* (US EPA 1992a), *Superfund Public Health Evaluation Manual* (US EPA 1986), US EPA's *Additional Environmental Fate Constants* (US EPA 1995), Hazardous Substance Release/Health Effects Database (ATSDR 2003), the RAIS database (DOE 2005), and the CHEMFACTS database (US EPA 2000). The VF_s for the residential and commercial/industrial scenarios is calculated using Equation 46 while the $VF_{s\text{-}cw}$ for the construction worker is calculated using Equation 47.

Equation 46
Derivation of the Volatilization Factor for Residential and Commercial/Industrial Scenarios

$$VF_s = \frac{Q/C_{vol} \times \left(3.14 \times D_A \times T\right)^{0.5} \times 10^{-4}}{\left(2 \times \rho_b \times D_A\right)}$$

Where:

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

Parameter	Definition (units)	Default
VF_s	Volatilization factor for soil (m^3/kg)	Chemical-specific
D_A	Apparent diffusivity (cm^2/s)	Chemical-specific
Q/C_{vol}	Inverse of the mean concentration at the center of a 0.5- acre-square source (g/m^2-s per kg/m^3)	68.18
T	Exposure interval (s)	9.5E+08
ρ_b	Dry soil bulk density (g/cm^3)	1.5
n	Total soil porosity 1 - (ρ_b/ρ_s)	0.43
θ_a	Air-filled soil porosity (n - θ_w)	0.17
θ_w	Water-filled soil porosity	0.26
ρ_s	Soil particle density (g/cm^3)	2.65
D_a	Diffusivity in air (cm^2/s)	Chemical-specific
H'	Dimensionless Henry's Law constant	Chemical-specific
D_w	Diffusivity in water (cm^2/s)	Chemical-specific
K_d	Soil-water partition coefficient (cm^3/g) = K_{oc} x f_{oc} (organics)	Chemical-specific
K_{oc}	Soil organic carbon partition coefficient (cm^3/g)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.0015

Equation 47
Derivation of the Volatilization Factor for Construction Worker Scenario

$$VF_{s-cw} = \left(\frac{(3.14 \times D_A \times T)^{0.5}}{2 \times \rho_b \times D_A} \right) \times 10^{-4} \times Q/C \times (1/F_D)$$

Where:

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

Parameter	Definition (units)	Default
VF_{s-cw}	Volatilization factor for soil, construction worker (m^3/kg)	Chemical-specific
D_A	Apparent diffusivity (cm^2/s)	Chemical-specific
Q/C	Inverse of the mean concentration at the center of a 0.5- acre-square source (g/m^2-s per kg/m^3)	14.31
T	Exposure interval (s)	3.15E+07
10^{-4}	Conversion factor (m^2/cm^2)	1E-04
F_D	Dispersion correction factor (unitless)	0.185
ρ_b	Dry soil bulk density (g/cm^3)	1.5
n	Total soil porosity 1 - (ρ_b/ρ_s)	0.43
θ_a	Air-filled soil porosity (n - θ_w)	0.17
θ_w	Water-filled soil porosity	0.26
ρ_s	Soil particle density (g/cm^3)	2.65
D_a	Diffusivity in air (cm^2/s)	Chemical-specific
H'	Dimensionless Henry's Law constant	Chemical-specific
D_w	Diffusivity in water (cm^2/s)	Chemical-specific
K_d	Soil-water partition coefficient (cm^3/g) = K_{oc} x f_{oc} (organics)	Chemical-specific
K_{oc}	Soil organic carbon partition coefficient (cm^3/g)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.0015

While most of the parameters used to calculate apparent diffusivity (D_A) are either chemical-specific or default values, several state-specific values were used which are more representative of soil conditions found in New Mexico. The default values for θ_w, θ_a, and ρ_b in Equations 46 and 47 are 0.26, 0.17 and 1.5 g/cm^3, respectively. These values represent mean values from a National Resources Conservation Service (NRCS) soil survey database for New Mexico that includes over 1200 sample points (U.S. Department of Agriculture 2000). US EPA guidance (US EPA 2001a) provides additional methodologies for estimating site-specific air-filled soil porosities and water-filled soil porosities.

It should be noted that the basic principle of the VF model (i.e., Henry's Law) is applicable only if the soil contaminant concentration is at or below soil saturation, C_{sat}. Above the soil saturation

limit, the model cannot predict an accurate VF-based SSL.

3.2 Soil Saturation Limit

C_{sat} describes a chemical-physical soil condition that integrates certain chemical-specific properties with physical attributes of the soil to estimate the contaminant concentration at which the soil pore water, pore air, and surface sorption sites are saturated with contaminants. Above this concentration, the contaminants may be present in free phase within the soil matrix – as non-aqueous phase liquids (NAPLs) for substances that are liquid at ambient soil temperatures, and pure solid phases for compounds that are solids at ambient soil temperatures (US EPA 1996a). Generic C_{sat} concentrations should not be interpreted as confirmation of a saturated soil condition, but as estimates of when this condition may occur. It should be noted that C_{sat} concentrations are not risk-based values. Instead, they correspond to a theoretical threshold above which free phase contaminant may exist. C_{sat} concentrations, therefore, serve to identify an upper limit to the applicability of generic risk-based soil criteria, because certain default assumptions and models used in the generic algorithms are not applicable when free phase contaminant is present in soil. The 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 VF-based screening levels that exceed the "sat" concentration are set equal to "C_{sat}" whereas for solids (e.g., PAHs), soil screening decisions are based on appropriate other pathways of concern at the site (e.g., ingestion and dermal contact). Equation 48, given below is used to calculate C_{sat} for each volatile contaminant considered within the SSLs.

Equation 48
Derivation of the Soil Saturation Limit

$$C_{sat} = \frac{S}{\rho_b}\left(K_d \rho_b + \theta_w + H'\theta_a\right)$$

Parameter	Definition (units)	Default
C_{sat}	Soil saturation concentration (mg/kg)	Chemical-specific
S	Solubility in water (mg/L-water)	Chemical-specific
ρ_b	Dry soil bulk density (kg/L)	1.5
K_d	Soil-water partition coefficient (L/kg; $K_{oc} \times f_{oc}$)	Chemical-specific
K_{oc}	Soil organic carbon/water partition coefficient (L/kg)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.0015
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.26
H´	Dimensionless Henry's Law constant	Chemical-specific
θ_a	Air-filled soil porosity (n- θ_w),(L_{air}/L_{soil})	0.17
n	Total soil porosity ($1 - (\rho_b/\rho_s)$), (L_{pore}/L_{soil})	0.43
ρ_s	Soil particle density (kg/L)	2.65

Chemical-specific parameters used in Equation 48 were obtained from physical-chemical information presented in several sources including: US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA 1996a and US EPA 2002a), the US EPA Regional

Screening Levels (US EPA 2016a), US EPA's *Basics of Pump and Treat Groundwater remediation Technology* (US EPA 1990), US EPA's *Dermal Exposure Assessment* (US EPA 1992a), *Superfund Public Health Evaluation Manual* (US EPA 1986), US EPA's *Additional Environmental Fate Constants* (US EPA 1995), Hazardous Substance Release/Health Effects Database (ATSDR 2003), the RAIS, CHEMFACTS, WATER9, and PHYSPROP databases, and EPISUITE.

3.3 Particulate Emission Factor

Inhalation of chemicals adsorbed to suspended respirable particles is assessed using a chemical-specific PEF, which relates the contaminant concentration in soil to the concentration of respirable particles in the air due to fugitive dust emissions from contaminated soils. This guidance addresses dust generated from open sources, which is termed "fugitive" because it is not discharged into the atmosphere in a confined flow stream. For further details on the methodology associated with the PEF model, the reader is referred to US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a) and *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (US EPA 2005b).

It is important to note that the PEF for use in evaluating exposure of residential and commercial/industrial receptors addresses only windborne dust emissions and does not consider emissions from traffic or other forms of mechanical disturbance, which could lead to a greater level of exposure. The PEF for use in evaluating construction worker exposures considers windborne dust emissions and emissions from vehicle traffic associated with construction activities. Therefore, the fugitive dust pathway should be considered carefully when developing the CSM at sites where receptors may be exposed to fugitive dusts by other mechanisms. Equation 49 is used to calculate a New Mexico region-specific PEF value, used for both the residential and commercial/industrial exposure scenarios. A scenario-specific PEF value was calculated for a construction worker receptor (PEF_{cw}) using Equation 50.

Equation 49
Derivation of the Particulate Emission Factor
Residential and Commercial/Industrial Scenarios

$$PEF = Q / C_{wind} \times \frac{3{,}600 \text{ sec / hr}}{0.036 \times (1 - V) \times \left(\frac{U_m}{U_t}\right)^3 \times F(x)}$$

Parameter	Definition (units)	Default
PEF	Particulate emission factor (m^3/kg)	6.61E+09
Q/C_{wind}	Inverse of a mean concentration at center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	81.85
V	Fraction of vegetative cover (unitless)	0.5
U_m	Mean annual windspeed (m/s)	4.02
U_t	Equivalent threshold value of windspeed at 7 m (m/s)	11.32
F(x)	Function dependent on U_m/U_t derived using Cowherd et al. (1985) (unitless)	0.0553

Equation 50
Derivation of the Particulate Emission Factor
Construction Worker Scenario

$$PEF_{CW} = Q / C_{CW} \times \frac{1}{F_D} \left[\frac{T \times A_R}{556 \times \left(\frac{W}{3}\right)^{0.4} \times \frac{(365 \text{ days / yr} - P)}{365 \text{ days / yr}} \times \sum VKT} \right]$$

Parameter	Definition (units)	Default
PEF_{CW}	Particulate emission factor for a construction worker (m^3/kg)	2.1E+06
Q/C_{CW}	Inverse of a mean concentration at center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	23.02
F_D	Dispersion correction factor (unitless)	0.185
T	Total time over which construction occurs (s)	7.2E+06
A_R	Surface area of road segment (m^2)	274.2
W	Mean vehicle weight (tons)	8
P	Number of days with at least 0.01 inches of precipitation (days/yr)	60
ΣVKT	sum of fleet vehicle kilometers traveled during the exposure duration (km)	168.75

3.4 Physical-Chemical Parameters

Several chemical-specific parameters are required for calculating SSLs including the organic carbon normalized soil-organic carbon/water partition coefficients for organic compounds (K_{oc}), the soil-water partition coefficient for organic and inorganic constituents (K_d), the solubility of a compound in water (S), Henry's Law constant (H), air diffusivity (D_a), water diffusivity (D_w),

molecular weight, the octanol-water partition coefficient (K_{ow}), and the dermal permeability coefficient in water (K_p). Prior to calculating site-specific SSLs, each relevant chemical specific parameter value presented in Appendix B should be checked against the most recent version of its source to determine if updated data are available. Tables B-1, B-2, and B-3 in Appendix B provide the chemical-specific parameters used in calculating the NMED SSLs. Chemical-specific parameters were selected from the following sources in the order listed:

- Organic carbon partition coefficient (K_{oc}; L/kg). US EPA (2012b) Estimation Program Interface (EPI) Suite software, v4.11.
- Soil-water partition coefficient (K_d; cm^3/g). For organics, $K_d = K_{oc}$ x fraction of organic carbon in soil, (f_{oc} NMED default value of 0.15%). For inorganics, 1) US EPA (2002a); 2) Baes (1984) Figure 2.31.
- Water solubility (S; mg/L at 25 °C). US EPA (2012b) EPI Suite software, v4.11.
- Henry's Law constant (H; atm-m^3/mole at 25 °C). 1) US EPA (2012b) EPI Suite software, v4.11: a) experimental values; b) estimated values via the bond method; c) estimated values via the group method; and 2) US EPA (2002a).
- Diffusivity in air (D_a; cm^2/s). 1) US EPA (2006) Water 9 v3.0; 2) US EPA (2002a).
- Diffusivity in water (D_w; cm^2/s). 1) US EPA (2006) Water 9 v3.0; 2) US EPA (2002a).
- Molecular weight (MW). US EPA (2012b) EPI Suite software, v4.11.
- Dermal permeability coefficient in water (Kp; cm/hr). US EPA (2012a) EPI Suite software, v.4.11.

3.4.1 Solubility, K_{ow}, and Henry's Law Constant

The solubility of a contaminant refers to the maximum amount that can be dissolved in a fixed volume of solvent, usually pure water, at a specific temperature and pH. A chemical with a high solubility readily dissolves in water, while a low solubility indicates an inability to dissolve. Water solubility is generally predicted based on correlations with the octanol-water partition coefficient (K_{ow}). Solubility is used to calculate soil saturation limits for the NMED SSLs.

The octanol-water partition coefficient (K_{ow}) of a chemical is the ratio of a chemical's solubility in octanol versus its solubility in water at equilibrium. Essentially, this chemical-specific property is used as an indication of a contaminant's propensity to migrate from soil to water. It is an important parameter and is used in the assessment of environmental fate and transport for organic chemicals.

The Henry's Law constant (H) is used when evaluating air exposure pathways. For all chemicals that are capable of exchanging across the air-water interface, there is a point at which the rate of volatilization into the air and dissolution to the water or soil will be equal. The ratio of gas- and liquid-phase concentrations of the chemical at this equilibrium point is represented by H, which is used to determine the rate at which a contaminant will volatilize from soil to air. Values for H may be calculated using the following equation and the values for S, vapor pressure (VP), and MW.

$$H = \frac{VP \times MW}{S}$$ **Equation 51**

The dimensionless form of Henry's Law constant (H′) used in calculating soil saturation limits and volatilization factors for the NMED SSLs was calculated by multiplying H by a factor of 41 to convert the Henry's Law constant to a unitless value.

3.4.2 Soil Organic Carbon/Water Partition Coefficients (K_{oc})

The soil organic carbon-water partition coefficient (K_{oc}) is a measure of a chemical's tendency to adsorb to organic carbon present in soil. High K_{oc} values indicate a tendency for the chemical to adsorb to soil particles rather than remain dissolved in the soil solution. Strongly adsorbed molecules will not migrate unless the soil particle to which they are adsorbed moves (as in erosion). K_{oc} values of less than 500 indicate weak adsorption and a potential for leaching. K_{oc} is calculated using the following equation:

$$K_{oc} = \frac{\text{concentration adsorbed/concentration dissolved}}{\%\ \text{organic carbon in soil}}$$ **Equation 52**

K_{oc} can also be calculated by dividing the K_d value by the fraction of organic carbon (f_{oc}) present in the soil or sediment. It should be noted that a strong linear relationship exists between K_{oc} and K_{ow} and that this relationship can be used to predict K_{oc}.

3.4.3 Soil/Water Partition Coefficients (K_d)

The soil-water partition coefficient (K_d) for organic chemicals is the ratio of a contaminant's distribution between soil and water particles. The soil-water partitioning behavior of nonionizing and ionizing organic compounds differs because the partitioning of ionizing organics can be influenced by soil pH. K_d values were used in calculating soil saturation limits and VFs used in developing the NMED SSLs.

For organic compounds, K_d represents the tendency of a chemical to adsorb to the organic carbon fraction in soils, and is represented by:

$$K_d = K_{oc} \times f_{oc}$$ **Equation 53**

Where:

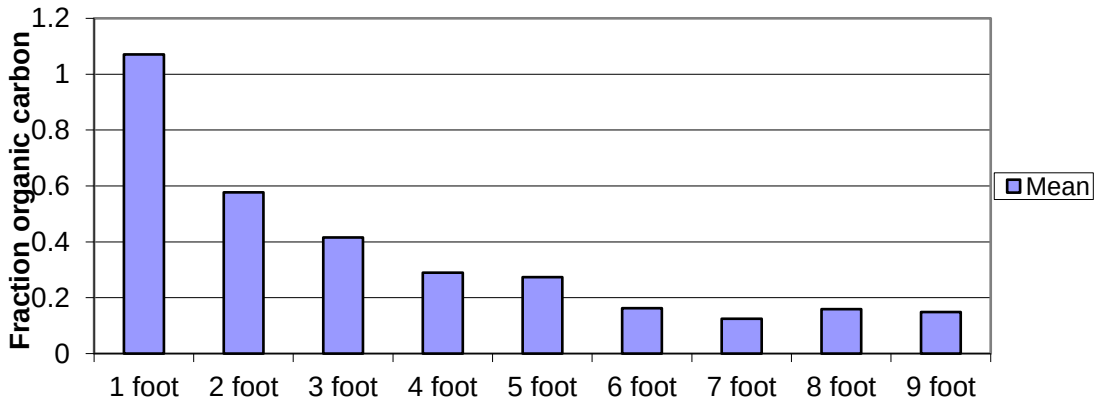
K_{oc} = organic carbon partition coefficient (L/kg or cm^3/g); and
f_{oc} = fraction of organic carbon in soil (mg/mg).

This relationship is generally valid for volatile halogenated hydrocarbons as long as the fraction of organic carbon in soil is above approximately 0.001 (0.1 percent) (Piwoni and Banaerjee, 1989 Schwarzenbach and Westall 1981). For low organic carbon soils ($f_{oc} < 0.001$), Piwoni and Banerjee (1989) developed the following empirical correlation for organic chemicals:

$$\log K_d = 1.01 \log K_{ow} - 0.36 \qquad \textbf{Equation 54}$$

The use of a fixed K_{oc} value in the soil-water partition equation for the migration to groundwater pathway is only valid for hydrophobic non-ionizing organic chemicals. For organic chemicals that ionize in the soil environment, existing in both neutral and ionized forms within the normal soil pH range, K_{oc} values must consider the relative proportions and differences in sorptive properties of these forms. For the equations and applications of developing K_{oc} values for ionizing organic acids as a function of pH, the reader is referred to US EPA 1996. The default value used for f_{oc} in development of NMED SSLs is 0.0015 (0.15%). This value represents the median value of 212 data points included in the NRCS soil survey database for New Mexico (U.S. Department of Agriculture 2000). Only samples collected from a depth of greater than 5 feet were included in the calculation of the mean f_{oc} value. Shallow soil samples tend to have higher f_{oc} values as shown in Figure 3-1. There is a steady decline in f_{oc} value with depth until approximately 5 feet bgs. Below 5 feet, there is little variability in the f_{oc} value. Because a lower f_{oc} value provides a more conservative calculation of SSL, a value representative of deeper soil conditions is used as the default value.

Figure 3-1 Mean Value - Fraction Organic Carbon (f_{oc})
All Counties in New Mexico



As with organic chemicals, development of the NMED SSLs for inorganic constituents (i.e., metals) requires a soil-water partition coefficient (K_d) for each contaminant. K_d values for metals are affected by a variety of soil conditions, most notably pH, oxidation-reduction conditions, iron oxide content, soil organic matter content, cation exchange capacity and major ion chemistry. US EPA developed default K_d values for metals using either an equilibrium geochemical speciation model (MINTEQ2) or from empirical pH-dependent adsorption relationships developed by US EPA's Office of Research and Development (EPA/ORD) (US EPA 1996a).

4.0 MIGRATION OF CONTAMINANTS TO GROUNDWATER

Generic SSLs were developed that address the potential for migration of contaminants from soil to groundwater. The methodology used to calculate generic SSLs addresses the potential leaching of contaminants from the vadose zone to groundwater. This method does not consider any additional attenuation associated with contaminant transport in groundwater. The SSLs developed from this analysis are risk-based values incorporating NMED-specific tap water SSLs or SSLs based on protection of groundwater. This methodology is modeled after US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA 1996a) and the *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (US EPA 2002a)*.

4.1 Overview of the SSL Model Approach

Two approaches to developing soil leachate-based SSLs (SL-SSLs) are presented, the generic model and the site-specific model. Both models use the same set of equations to calculate SL-SSLs and are based on leaching to groundwater scenarios that NMED believes are protective of groundwater. The generic model calculates SL-SSLs using default parameter values generally representative of conditions in New Mexico. These values are presented in Tables B-1 and B-2 of Appendix B. The site-specific model provides the flexibility of using site-specific meteorological, soil and hydrological data to calculate SSLs, while retaining the simplicity and ease of use associated with the generic model.

The development of SL-SSLs is based upon a two-step process. The first step is the development of a Dilution Attenuation Factor (DAF). The DAF accounts for leachate mixing in the aquifer. A leachate concentration that is protective of groundwater is back calculated by multiplying the groundwater standard for a given constituent by the DAF. That leachate concentration is then used to back calculate a SL-SSL that is protective of groundwater using a simple linear equilibrium soil/water partition equation. For the generic SL-SSL approach, default parameter values are used for all non-chemical specific parameters. At sites that are not adequately represented by the default values and where more site-specific data are available, it may be more appropriate to use the site-specific SL-SSL model. The site-specific model uses the same spreadsheet equations to calculate SL-SSLs as those in the generic look-up table; however, site-specific data are used in the site-specific model.

The following sections of this document provide a general description of the leaching to groundwater pathway SSL model (generic and site-specific) including the assumptions, equations, and input parameters. Justification for the default parameters used in the generic model is also provided. Additionally, a sensitivity analysis was performed on each of the input parameters to provide guidance on when use of the site-specific model may be warranted. Applicability and limitations of the generic and site-specific models are also presented.

4.2 Model Assumptions

Conservative assumptions regarding the release and distribution of contaminants in the subsurface that are incorporated into the SSL methodology include the following:

- The source is infinite (a constant concentration is maintained for the duration of the exposure period).

- Contamination is uniformly distributed from the surface to the water table.

- Soil/water partitioning is instantaneous and follows a linear equilibrium isotherm.

- There is no attenuation of the contaminant in soil or the aquifer (i.e., no irreversible adsorption, chemical transformation or biological degradation).

- The potentially impacted aquifer is unconfined and unconsolidated with homogenous and isotropic hydrologic properties.

- The receptor well (point of exposure) is at the downgradient edge of the source and is screened within the potentially impacted aquifer.

- NAPLs are not present.

4.3 Soil Water Partition Equation

US EPA's *Supplemental Soil Screening Guidance: Technical Background Document* (US EPA 1996a) and *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a) developed an equation to estimate contaminant release in soil leachate based on the Freundlich adsorption isotherm. The Freundlich equation was modified to relate the sorbed concentration to the total concentration measured in a soil sample (which includes contaminants associated with solid soil, soil-water and soil-air components) (Feenstra 1991). Equation 55, given below, is used to calculate SSLs corresponding to target soil leachate concentrations (C_w).

Equation 55
Soil Screening Level for Leaching to Groundwater Pathway

$$SL\text{-}SSL = C_w \text{ x} \left[K_d + \left(\frac{\theta_w + \theta_a H'}{\rho_b} \right) \right]$$

Parameter	Definition (units)	Default
SL-SSL	Soil Screening Level for migration to groundwater pathway (mg/kg)	Chemical-Specific
C_w	Target soil leachate concentration (mg/L)	Chemical-Specific
K_d	Soil /water partition coefficient (L/kg)	Chemical-Specific
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.26
θ_a	Air-filled soil porosity (L_{air}/L_{soil}), n - θ_w	0.17
n	Total soil porosity (L_{pore}/L_{soil}), 1 - (ρ_b/ρ_s)	0.43
ρ_s	Soil particle density (kg/L)	2.65
ρ_b	Dry soil bulk density (kg/L)	1.5
H´	Dimensionless Henry's Law constant	Chemical-Specific

Target soil leachate concentrations (C_w) are equivalent to the NMED-specific tap water SSLs multiplied by a DAF. SL-SSLs were calculated using the tap water SSL, the NM groundwater protection criterion (20.6.2 New Mexico Administrative Code, NMAC), and the Federal Maximum Contaminant Level (MCL) as follows:

C_w = Tap Water SSL x DAF **Equation 56**
or
C_w = WQCC x DAF
or
C_w = MCL x DAF

For screening purposes, the least conservative SL-SSL may be applied. Table A-3 summarizes all SL-SSLs while Table A-1 contains the least conservative SL-SSL for use in screening assessments.

The derivation of the DAF is discussed in subsequent sections of this document.

4.4 Dilution Attenuation Factor

Contaminants transported as a leachate through soil to groundwater are affected by physical, chemical, and biological processes that can significantly reduce their concentration. These processes include adsorption, biological degradation, chemical transformation, and dilution from mixing of the leachate with groundwater. The total reduction in concentration between the source of the contaminant (vadose zone soil) and the point of groundwater withdrawal is defined as the ratio of contaminant concentration in soil leachate to the concentration in groundwater at the point of withdrawal. This ratio is termed a dilution/attenuation factor (DAF; US EPA 1996a

and 1996b). The higher the DAF value the greater the degree of dilution and attenuation of contaminants along the migration flow path. A DAF of 1 implies no reduction in contaminant concentration occurs.

Development of New Mexico SL-SSLs considers only the dilution of contaminant concentration through mixing with groundwater in the aquifer directly beneath the source. This is consistent with the conservative assumptions used in the SSL methodology including an infinite source, soil contamination extending from surface to groundwater and the point of exposure occurring at the downgradient edge of the source. The ratio of contaminant concentration in soil leachate to the concentration in groundwater at the point of withdrawal that considers only dilution processes is calculated using the simple water balance equation (Equation 57), described below.

Equation 57
Dilution/Attenuation Factor (DAF)

$$DAF = 1 + \left(\frac{K \times i \times D}{I \times L} \right)$$

Where:

$$D = \left(0.0112 \times L^2 \right)^{0.5} + D_a \left(1 - \exp \left[\frac{-L \times I}{K \times i \times D_a} \right] \right)$$

Parameter	Definition (units)	Default
DAF	Dilution/attenuation factor (unitless)	Site-Specific
K	Aquifer hydraulic conductivity (m/yr)	Site-Specific
i	Hydraulic gradient (m/m)	Site-Specific
D	Mixing zone depth (m)	Site-Specific
I	Infiltration rate (m/yr)	Site-Specific
L	Source length parallel to groundwater flow (m)	Site-Specific
D_a	Aquifer thickness (m)	Site-Specific

Most of these parameters are available from routine environmental site investigations. The mixing zone depth incorporates one additional parameter, the aquifer thickness (D_a).

For the calculation of SL-SSLs, the DAF is used to back calculate the target soil leachate concentration (C_w in Equation 56) from an appropriate groundwater concentration, such as the tap water SSL, a Water Quality Control Commission (WQCC) standard, or an MCL. For example, if the WQCC standard for a constituent is 0.1 mg/L and the DAF is 20, the target soil leachate concentration would be 2 mg/L.

The US EPA conducted an extensive evaluation of the range and distribution of DAFs to select a default value to be used for developing generic SSLs that would be reasonably protective of groundwater quality (US EPA 1996a, 1996b, and 2002a). The evaluation included a probabilistic modeling exercise using US EPA's Composite Model for Leachate Migration with Transformation Products (CMTP). A cumulative frequency distribution of DAF values was

developed from the model output. Results of the Monte Carlo modeling analysis indicate that for a 0.5-acre source area a DAF of approximately 170 is protective of groundwater at 90 percent of the sites. Groundwater is protected at 95 percent of the sites with a DAF of 7.

US EPA applied the simple SL-SSL water balance dilution model (Equation 56) to 300 sites included in surveys of hydrogeologic investigations to further evaluate the range and distribution of DAF values. Results of this analysis indicated that a DAF of 10 was protective of groundwater for a 30-acre source and that a DAF of 20 was protective of groundwater for a 0.5 acre-source (US EPA 1996a, 1996b, and 2002a).

An assessment was performed of US EPA's methodology to determine whether a default DAF value of 20 for a 0.5-acre source, and a DAF of 10 for a 30-acre source, would be appropriate for use as default values for sites in New Mexico. Typical New Mexico conditions may be notably different than conditions represented by areas included in the US EPA analysis of DAFs. For example, infiltration rates across much of New Mexico are substantially less than the average range of 0.15 to 0.24 m/yr reported for many of the hydrogeologic regions used in the US EPA analysis. In addition, effective porosity was assumed to be 0.35, presumably because this value is representative of the most prevalent aquifer type in the databases used (US EPA 1996a). However, the regions included in the US EPA analysis also contain extensive glacial, regolith, lacustrine, swamp, and marsh deposits which have high percentages of fine-grained sediments and thus, are not representative of typical New Mexico sandy soils. Sandy soils typically have higher hydraulic conductivities than more fine-grained soils and subsequently higher Darcian velocities, under equal hydraulic gradient. According to the DAF equation (Equation 57), soils with relatively greater hydraulic conductivities will tend to result in a higher calculated DAF.

An assessment was made of input parameters to the DAF equation. In order to support a DAF that is protective of the most vulnerable groundwater environments in New Mexico (i.e., areas close to perennial streams or where groundwater is very shallow), environmental parameters typical of those areas in New Mexico were used to assess the DAF. This assessment indicated that the DAF is most sensitive to variations in hydraulic conductivity. This is because this parameter exhibits such large variations in the natural environment. If a hydraulic conductivity value representative of a fine-grained sand is used in the DAF equation, along with an infiltration rate representative of New Mexico's arid to semi-arid environments, then the result is a DAF of approximately 20. NMED believes that a DAF of 20 for a 0.5-acre source area is protective of groundwater in New Mexico. If the default DAF is not representative of conditions at a specific site, then it is appropriate to calculate a site-specific DAF based upon available site data.

4.5 Limitations on the Use of the Dilution Attenuation Factor

Because of assumptions used in SL-SSL model approach, use of the DAF model may be inappropriate for certain conditions, including sites where:

- Adsorption or degradation processes are expected to significantly attenuate contaminant concentrations in the soil or aquifer media;
- Saturated thickness is significantly less than 12 meters (m) thick;

- Fractured rock or karst aquifer types exist (violates the unconfined, unconsolidated, homogeneous, isotropic assumptions);
- Facilitated transport is significant (colloidal transport, transport via dissolved organic matter, or transport via solvents other than water); and/or
- NAPLs are present.

For sites that have these types of conditions, consideration should be given to application of a more detailed site-specific analysis than either the generic or site-specific models described herein.

4.6 Generic SL-SSLs for Protection of Groundwater

The migration to groundwater pathway model, incorporating the assumptions previously stated, the soil-water partition equation, and the DAF, was used to develop NMED SSLs. Default values based on conditions predominant in New Mexico were used for the input parameters in the soil-water partition equation. The NMED SL-SSLs are presented for both default DAF values of 1 and 20.

Target soil leachate concentrations (C_w) are equivalent to the appropriate groundwater standards multiplied by a DAF. To maintain an approach that is protective of groundwater quality in the development of generic SL-SSLs, a DAF of 20 is selected as reasonably protective. However, SL-SSLs are provided for two DAFs in Appendix A. The use of the SL-SSL listed for a DAF of 20 is advised unless site-specific data on hydrologic conditions are available, and these indicate that the generic DAF is not representative of site conditions. As will be demonstrated in the sensitivity analysis section of this document, calculation of a SL-SSL using the migration to groundwater pathway model is most sensitive to the DAF. SL-SSLs for a DAF of 1 are provided for convenience to the user. If data on hydrologic conditions are readily available, a site-specific DAF can be calculated and multiplied by the generic SL-SSL for a DAF of 1 to provide a site-specific target soil leachate concentration.

The generic approach may be inappropriate for use at sites where conditions are substantially different from the default values used to develop the generic soil leachate concentrations.

4.7 Development of Site-Specific SL-SSLs for Protection of Groundwater

New Mexico, as with any other state, offers a variety of geologic and hydrologic conditions that may not be readily represented by a single default parameter value.

Site specific conditions may differ considerably from the typical or average conditions represented by the default values used to calculate generic SL-SSLs. The site-specific model can be used to address the variability inherent in environmental conditions across and within the state.

Application of the site-specific model to develop target soil leachate concentrations is the same as the generic approach except that site-specific values are used. Use of the site-specific model

approach may incorporate replacement of all default values used for the generic SL-SSLs with site-specific values or may only include substitution of a single key parameter, such as hydraulic conductivity. The decision to use the site-specific model approach instead of the generic approach should be based on consideration of the sensitivity of the calculated SL-SSL to specific parameters and the availability of those parameters as site-specific data. Sufficient site-specific data may be available such that each of the default values used for developing generic SL-SSLs can be readily substituted with a more representative site-derived value. Conversely, limited site-specific data may restrict the number of default values that can be replaced.

The NMED SL-SSLs are generally more sensitive to the DAF than to other parameters in the soil-water partition equation. Fortunately, information needed to derive the DAF is usually available for sites that have undergone even the most basic levels of environmental investigation. Apart from the DAF, target soil leachate concentrations are most sensitive to the soil-water partition coefficient (K_d) as the values for this parameter can range over several orders of magnitude, particularly for metals. Although the K_d term may be critical in developing protective target soil leachate concentrations, information required to evaluate this parameter is more difficult to obtain and less likely to be available. Porosity and bulk density are not particularly sensitive because of the relatively small range of values encountered in subsurface conditions.

Using benzene as a representative contaminant, a sensitivity analysis was performed to compare a generic soil leachate SSL to site-specific model results simulating a range of model input parameters that might be representative of different conditions in New Mexico. The generic soil leachate concentration calculated using the New Mexico default values and a DAF of 1 is 2.8 µg/kg. These results are summarized in Table 4-1. As shown, the resulting SL-SSLs for benzene range from 1.3 to 6.1 µg/kg for the various sensitivity simulations compared to the generic SSL of 2.8 µg/kg. These results indicate that the calculation of SSLs using the site-specific approach is not overly sensitive to the reasonable range of porosity (air and water filled), bulk density and fraction of organic carbon (f_{oc}) expected for New Mexico or even for a range of values for chemical-specific properties. The generic SL-SSL for benzene of 2.8 µg/kg is representative of values that could be calculated using a spectrum of input parameters, exclusive of the DAF term. Unless there are sufficient data to calculate a site-specific DAF, there is little benefit derived from using the site-specific model approach instead of the generic SL-SSL.

Table 4-1. Input Parameters and Resulting SL-SSLs for the Sensitivity Analysis of the Soil-Water Partition Equation - Migration to Groundwater Pathway Model

Input parameter (NMED default value)	Sensitivity Analysis Values	Resulting SL-SSL
Bulk density (default value = 1.55 gm/cm)	Lower Limit = 1.20 Upper Limit = 1.90	3.4 2.5
Air filled porosity (default value = 0.18)	Lower Limit = 0.04[a] Upper Limit = 0.25[b]	1.3 3.5
Fraction organic carbon (default value = 0.0015)	Lower Limit = 0.0005 Upper Limit = 0.007	2.2 6.1
Volume water content (default value = 0.26)	Lower Limit = 0.05[c] Upper Limit = 0.40[c]	1.8 3.5
K_{oc} (default value = 58.9 ml/g)	Lower Limit = 30 Upper Limit = 120	2.4 3.7
Dimensionless Henry's Law constant (default value = 0.228)	Lower Limit = 0.1 Upper Limit = 0.4	2.7 3.0
[a] total porosity was reduced from 0.44 to 0.10 for this simulation [b] total porosity was increased from 0.44 to 0.6 for this simulation [c] total porosity remained at 0.44 for this simulation.		

As previously stated, calculation of SL-SSLs is most sensitive to the DAF term. The input parameter values and resulting DAFs for the sensitivity analysis are included in Table 4-2. Effects on the DAFs are, from greatest to least, the Darcian velocity (hydraulic conductivity multiplied by the hydraulic gradient), infiltration rates, size of the contaminated area, and the aquifer thickness. Corresponding effects on DAFs for each of these parameters and discussion of the relevance of the use of default values versus site-specific conditions are summarized below.

Table 4-2. Input Parameters and Resulting DAFs for the Sensitivity Analysis of the Dilution Attenuation Factor-Migration to Groundwater Pathway Model

Parameter	Groundwater Velocity (m/yr)	Infiltration Rate (m/yr)	Source Length (m)	Aquifer thickness (m)	Mixing Zone Depth (m)	Dilution Attenuation Factor (DAF)
Groundwater Velocity	*4.7.1 2.2*	0.13	45	12	7.15	3.7
Groundwater Velocity	22	0.13	45	12	5.03	19.9
Groundwater Velocity	220	0.13	45	12	4.79	181.1
Infiltration Rate	22	0.065	45	12	4.89	37.8
Infiltration Rate	22	0.13	45	12	5.03	19.9
Infiltration Rate	22	0.26	45	12	5.28	10.9
Source Length	22	0.13	22.5	12	2.51	19.9
Source Length	22	0.13	45	12	5.03	19.9
Source Length	22	0.13	348.4	12	38.76*	6.8
Aquifer Thickness	22	0.13	45	3	5.02*	12.3
Aquifer Thickness	22	0.13	45	12	5.03	19.9
Aquifer Thickness	22	0.13	45	48	5.03	19.9

Note: If mixing zone depth calculation is greater than aquifer thickness, then aquifer thickness is used to calculate the DAF.

Higher Darcian velocity results in higher DAFs. Slower mixing of groundwater with soil leachate occurs at lower groundwater velocity. Thus, using a lower velocity constitutes a more conservative approach. Sandy soils typically have higher hydraulic conductivities than more fine-grained soils and subsequently higher Darcian velocity (under equal hydraulic gradient). Use of a sandy soil type will generally be less conservative (result in higher DAFs) with respect to protection of groundwater quality.

Lower infiltration rates result in higher DAFs. Therefore, using a higher infiltration rate is a more conservative approach (results in a lower DAF).

Larger source sizes result in lower DAFs. The default DAF used to develop SL-SSLs for a 0.5-acre source may not be protective of groundwater at sites larger than 0.5 acre. However, the selection of a second source size is arbitrary. If generic SL-SSLs are developed for a 30-acre

source, then those values are considered overly conservative for a 12-acre source. Conversely, SL-SSLs developed for a 30-acre source will be less protective of a 40-acre source. Rather than develop a separate set of generic SSLs for a second (or third or fourth) source size, the following two approaches are proposed.

- As the size of the source area increases, the assumptions underlying the generic model are less applicable. One of the conservative assumptions in the generic SSL approach is the uniform distribution of contaminants throughout the vadose zone. There are few sites that have relatively uniform soil contamination (both laterally and vertically) of a single constituent in an area of greater than 0.5 acres (22,000 ft^2). Soil contamination at large facilities (such as federal facilities) are usually concentrated in discrete portions of the site. Contamination at large sites is commonly the result of multiple sources. It is advisable to attempt to subdivide the facility by source and contaminant type and then apply generic SSLs to those smaller source areas.
- If this approach is impractical, calculation of site-specific DAFs is recommended. Most of the parameters required for these calculations are available from routine environmental site investigations or can be reasonably estimated from general geologic and hydrologic studies.

Thin aquifers will result in lower DAFs. The nominal aquifer thickness used in the sensitivity analysis was 12 m. Reducing the aquifer thickness to 3 m results in a 40 percent reduction in the DAF. Increasing the aquifer thickness beyond the nominal value has very little impact.

The significant effects of the DAF on the calculation of SL-SSLs, coupled with the common availability of site-specific data used to calculate the DAF, suggest that use of the site-specific modeling approach should at least incorporate recalculation of the DAF term. If data are available that indicate soil properties significantly different than the default values (such as high or low f_{oc} for organic contaminants, or highly acidic or basic conditions for metal contaminants) the K_d term should also be evaluated and recalculated.

4.8 Detailed Model Analysis for SL-SSLs Development

Sites that have complex or heterogeneous subsurface conditions may require more detailed evaluation for development of SL-SSLs that are reasonably, but not overly, protective of groundwater and surface water resources. These types of sites may require more complex models that can address a wide range of variability in environmental site conditions including soil properties, contaminant mass concentration and distribution, contaminant degradation and transformation, recharge rates and recharge concentration, and depth to the water table. Model codes suitable for these types of more detailed analyses range from simple one-dimensional analytical models to complex three-dimensional numerical models. Note that resource requirements (data, time, and cost) increase for the more complex codes. The selection of an appropriate code needs to balance the required accuracy of the output with the level of effort necessary to develop the model.

4.9 Summary of the Migration to Groundwater Pathway SL-SSLs

SL-SSLs for New Mexico have been developed for the migration to groundwater pathway, and are provided in Table A-3 of Appendix A. SL-SSLs were derived using two criteria: tap water screening levels and the NMED groundwater and surface water protection levels (20.6.2 NMAC), and/or Federal MCLs. The highest SL-SSL for a chemical based on a DAF of 20 is listed in Table A-1 and should be applied for initial screening. This approach maintains the conservative approach of the SL-SSL methodology, is protective of groundwater quality under a wide range of site conditions and complies with the groundwater protection requirements in 20.6.2 NMAC.

Soil contaminant concentrations are compared directly to the generic target soil leachate concentrations to determine if additional investigation is necessary to evaluate potential leaching and migration of contaminants from the vadose zone to groundwater in excess of NMED groundwater protection criteria, as shown in Equation 58.

$$\text{Is Site Concentration} \leq \text{SL} - \text{SSL}\,? \qquad \textbf{Equation 58}$$

All soil data, regardless of depth of detection, should be used in the evaluation of the migration to groundwater pathway. For the initial screen, the maximum detected concentration in soil should be applied.

As it is noted that the underlying assumptions (Section 4.2) used to develop the generic SL-SSL may result in overly conservative values not representative of actual site conditions, site-specific SL-SSLs can be developed by substituting site-related data for the default values in the leaching to groundwater pathway model. SL-SSLs developed from this model are most sensitive to the DAF. SL-SSLs are also provided in the lookup table for a DAF of 1. If data on hydrologic conditions are readily available, a site-specific DAF can be calculated.

In addition to use of migration to groundwater SL-SSLs, additional lines of evidence may be used to address the potential for contaminant migration. These factors may include: removal actions (i.e., removal of source material), vertical profile of contamination in soil (defined vertical extent) combined with depth to groundwater, physical-chemical parameters (e.g., low Kd for metals), lack of presence of liquids to push contaminant downward, and geology/hydrology. Please note that depth to groundwater alone is not a sufficient line of evidence to justify the migration to groundwater pathway as incomplete. If the depth and area of contamination along with site-specific infiltration rates are known, mass-limit soil screening levels for migration to groundwater may also be calculated. US EPA 2002a (or most current) guidance should be followed for determining site-specific mass-limit SL-SSLs.

5.0 USE OF THE SSLs

For screening sites with multiple contaminants, the following procedure should be followed: take the site-specific concentration (first step screening assessments should use the maximum reported concentration) and divide by the SSL concentration for each analyte. For multiple contaminants, simply add the ratio for each chemical. For carcinogens, multiply the sum by the

NMED target risk level of 1E-05 as shown in Equation 59. Equation 60 shows the sum of the ratios is multiplied by the NMED target hazard of 1.0 for noncarcinogens. Note that a chemical may exhibit both carcinogenic and noncarcinogenic toxicity (e.g., arsenic). For these chemicals, impact of SSLs based on both forms of toxicity must be evaluated (i.e., both site cancer risk and a site HI would be required for arsenic and other chemicals with both forms of toxicity).

$$\text{Site Risk} = \left(\frac{\text{conc}_x}{\text{SSL}_x} + \frac{\text{conc}_y}{\text{SSL}_y} + \frac{\text{conc}_z}{\text{SSL}_z} + \ldots + \frac{\text{conc}_i}{\text{SSL}_i} \right) \times 10^{-5} \qquad \textbf{Equation 59}$$

$$\text{Site Hazard Index (HI)} = \left(\frac{\text{conc}_x}{\text{SSL}_x} + \frac{\text{conc}_y}{\text{SSL}_y} + \frac{\text{conc}_z}{\text{SSL}_z} + \ldots + \frac{\text{conc}_i}{\text{SSL}_i} \right) \times 1 \qquad \textbf{Equation 60}$$

Site risks and hazard indices for any additional completed exposure pathways not included in the SSLs (e.g., vapor intrusion or ingestion of potentially contaminated produce/meat/dairy) should be added to the results of Equations 59 and 60. For noncarcinogenic effects, constituents can be grouped according to the same toxic endpoint and/or mechanism of action. The sources provided in Section 2.1 should be consulted to determine the endpoint and/or target organ system. Note: lead should be evaluated separately and not included in the HI. Similarly, risks from TPH should be evaluated separately if the indicator compounds have been included in the site risk and/or HI, to prevent over counting exposure.

Equations 59 and 60 do not apply to the soil-to-groundwater pathway. As discussed in Section 4.9, evaluation of the soil-to-groundwater pathway is a simple comparison of site data to SL-SSLs (see Equation 58) and does not represent an estimate of potential risk or hazard.

It is important to remember that site concentrations should be developed for each receptor and corresponding soil horizons, or exposure intervals. As discussed in Section 2.7.5 and summarized in Table 2-6, it is assumed that residential and construction worker receptors are exposed to soil from 0-10 ft bgs, while commercial/industrial receptors are exposed to soil 0-1 ft bgs. For the vapor intrusion and soil-to-groundwater migration pathways, maximum concentrations regardless of sampling depth should be considered for all receptors.

Site risks less than the NMED target level of 1E-05 and hazard indices less than the NMED target level of one (1) indicate that concentrations at the site are unlikely to result in adverse health impacts. If the total cancer risk is greater than the target risk level of 1E-5 or if the hazard index is greater than one, concentrations at the site warrant further, site-specific evaluation. Further site-specific evaluation may include refinement of receptor-specific exposure point concentrations via calculation of UCLs (Section 2.5). The calculated UCLs may then be used as the input concentrations for Equations 59 and 60. As stated in Section 1.2, further evaluation may also include additional sampling to better characterize the nature and extent of contamination, consideration of background levels, reevaluation of COPCs or associated risk and hazard using site-specific parameters, and/or a reassessment of the assumptions associated with the generic NMED SSLs.

As with any risk-based tool, the potential exists for misapplication. In most cases the root cause will be a lack of understanding of the intended use of NMED SSLs. In order to prevent misuse of SSLs, the following should be avoided:

- Applying SSLs to a site without adequately developing a CSM that identifies relevant exposure pathways and exposure scenarios,
- Failing to consider additional exposure pathways not included in the SSLs,
- Using the SSLs as cleanup levels without verifying numbers with a toxicologist or risk assessor, and
- Failing to consider the effects of additivity when screening multiple chemicals.

When generic NMED SSLs are used for screening level evaluations at a facility, site-specific conditions must be evaluated for each receptor to determine if the exposure assumptions associated with the generic NMED SSLs are appropriate for comparison with the available site data. The exposure assumptions for each receptor on which the generic NMED SSLs are based are shown in Table A-2. Therefore, Table A-2 should be consulted when the generic NMED SSLs are being applied at a facility. If the exposure assumptions presented in Table A-2 are not protective of the exposure and types of receptors found at a facility, NMED should be consulted to determine if refinement of the generic SSLs based on site-specific exposure parameters is appropriate.

5.1 Alternative Evaluation for Lead

Exposure to lead can result in neurotoxic and developmental effects. The primary receptors of concern are children, whose nervous systems are still undergoing development and who also exhibit behavioral tendencies that increase their likelihood of exposure (e.g., pica). These effects may occur at exposures so low that they may be considered to have no threshold and are evaluated based on a blood lead level (rather than an external dose as reflected in the RfD/RfC methodology). Therefore, US EPA views it to be inappropriate to develop noncarcinogenic "safe" exposure levels (i.e., RfDs) for lead. Instead, US EPA's lead assessment workgroup has recommended the use of the IEUBK model that relates measured lead concentrations in environmental media with an estimated blood-lead level for assessing risks to residential receptors (US EPA 2016h). The model is used to calculate a blood lead level in children when evaluating residential land use and in adults (based on a pregnant mother's capacity to contribute to fetal blood lead levels). However, US EPA recommends the use of the Adult Lead Methodology (ALM) for adults in evaluating occupational scenarios at sites where access by children is reliably restricted (US EPA 2016h). The NMED SSLs presented in Appendix A include default values for lead that were calculated by using the US EPA methodologies to back-calculate a soil concentration for each receptor that would not result in an estimated blood-lead concentration of 10 micrograms per deciliter (μg/dL) or greater (residential adult of 400 mg/kg and industrial and construction worker of 800 mg/kg). If the screening levels for lead are exceeded, it is recommended that site-specific bioavailability of lead using the US EPA's *in-vitro* bioaccessibility assay for lead be used to refine the screening levels. Note that if site-specific

screening levels are defined, the exposure to a typical/hypothetical child resident must not have an estimated risk exceeding 5%, or a resulting blood lead level of more than 10 µg/dL (US EPA 2016h).

5.2 Use of Chromium Screening Levels

Elemental chromium (Cr) is naturally present and considered stable in the ambient environment in one of two valence states: chromium (III) and chromium (VI). Chromium (III) occurs in chromite compounds or minerals and concentrations in soil/groundwater result from the weathering of minerals. Chromium (III) is the most stable state of environmental chromium; chromium (VI) in the environment is man-made, present in chromate and dichromate compounds, and is the more toxic of the oxidation states. (http://rais.ornl.gov/tox/profiles/chromium.html#t21).

The oxidation state of Cr has a significant effect on its transport and fate in the environment. The equilibrium distribution of the Cr between the two oxidation states is controlled by the redox environment. Oxidation depends on a variety of factors and is a function of pH and the rate of electron exchange, or standard reduction potential (Eh). Chromium (VI) is converted to the less toxic and much less mobile form of chromium (III) by reduction reactions. The corresponding oxidation of chromium (III) to chromium (VI) can also occur under oxidizing conditions.

The degree to which chromium (III) can interact with other soil constituents is limited by the fact that most chromium (III) is present in the form of insoluble chromium oxide precipitates rendering chromium (III) relatively stable in most soils. Oxidation of chromium (III) to chromium (VI) can occur under specific environmental conditions with influencing factors including the soil pH, chromium (III) concentration, presence of competing metal ions, availability of manganese oxides, presence of chelating agents (i.e., low molecular weight organic compounds), and soil water activity. Chromium (III) oxidation is favored under acidic conditions, where the increased solubility of chromium (III) at lower pH enables increased contact with oxidizing agents. Aside from decreasing soil pH, chromium (III) solubility is enhanced by chelation to low molecular weight compounds such as citric or fulvic acids. Conversely, factors influencing the reduction of chromium (VI) to chromium (III) in soil include soil pH, the presence of electron donors such as organic matter or ferrous ions, and soil oxygen levels (CEQG, 1999). Chromium reducing action of organic matter increases with decreasing pH.

Figure 5-1 (TCEQ, 2002) shows a generalized Eh-pH diagram for the chromium-water system. Chromium (III) exists over a wide range of Eh and pH conditions [e.g., Cr^{3+}, $Cr(OH)_3$, and CrO_2^-] while chromium (VI) exists only in strongly oxidizing conditions (e.g., $HCrO^-_4$ and CrO^2_4).

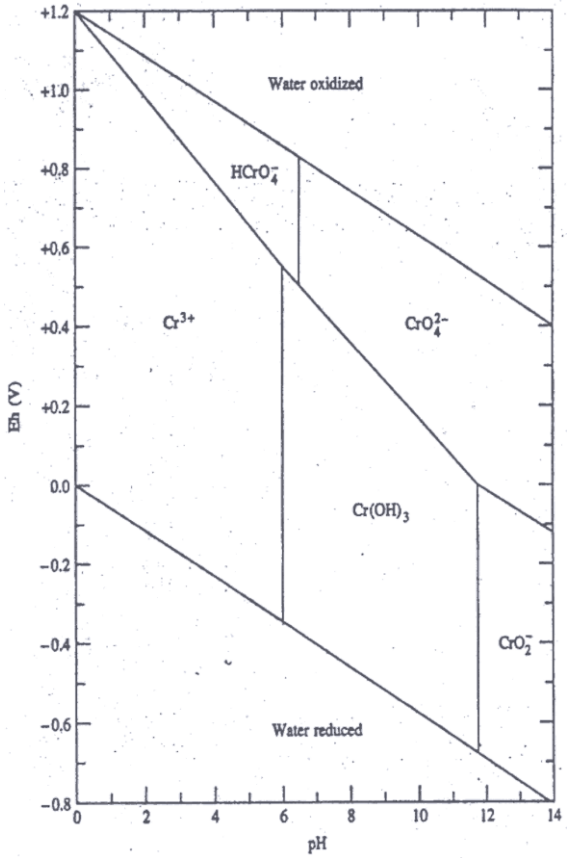


Figure 5-1. Eh-pH Diagram for Chromium

Generally, groundwater containing high concentrations of chromium is more likely to be comprised of chromium (VI) than chromium (III) because chromium (III) is more likely to have precipitated as Cr_2O_3 x H_2O and, to a lesser extent, adsorbed. Chromium (VI) is highly mobile in groundwaters with neutral to basic pH. In acidic groundwaters chromium (VI) can be moderately adsorbed by pH-dependent minerals such as iron and aluminum oxides. Under favorable conditions, chromium (VI) reduces to chromium (III) rapidly via ferrous iron, organic matter, and microbes. The oxidation of chromium (III) to chromium (VI) by dissolved oxygen and monoxides is kinetically slower (TCEQ, 2002). Redox conditions and pH dominate Cr speciation and thus are important parameters required for assessment of groundwater data.

The RSL tables no longer contain risk-based screening levels for total chromium (with the exception of air). The US EPA deleted the total chromium values due to uncertainty associated with the previously applied ratio of trivalent to hexavalent chromium. The concern was that an assumed ratio (1:6) had the potential to both under- and over-estimate risk.

For sites where chromium is to be included for analysis, a tiered process should be applied. If a review of site-specific geology and geochemistry indicates conditions are not favorable for the possible presence of chromium (VI), additional sampling may be conducted to demonstrate that total chromium is representative of only chromium (III). If site-specific speciated data demonstrate the absence of chromium (VI) in background and/or site soil, the use of the chromium (III) SSLs may be warranted. However, if there is site history sufficient to identify

chromium (VI) as a potential site contaminant, such as the site previously housed a plating operation or soil/water chemistry may allow for speciation, analyses of media (soil and/or groundwater) should include hexavalent and total chromium in the analytical suite along with determination of pH (water samples) and Eh to assess chemical state. Comparison of the species-specific data can be compared to representative background concentrations.

If site history does not indicate a known source for chromium (VI), the data (soil and/or groundwater) should be analyzed for total chromium. If the site levels of total chromium are within background, no additional analyses would be required (chromium would drop from the risk assessment as a constituent of concern). However, if the total chromium concentrations are statistically different (using a 95% confidence level) from background for soil or if chromium appears to be a site contaminant in groundwater, a two-tiered approach should be applied:

1. A more detailed review of the site history should be conducted to see if there were any potential sources for chromium (VI) or any processes that could have resulted in an alteration of speciation (such as introduction of acids). If there is no potential source, or it does not appear that any other chemicals or contaminants are present that may have altered the speciation of Cr, and this can be documented, no additional analyses will be required, and the data may be evaluated as total chromium. Table A-1 includes derived screening levels for total chromium, using the methodology outlined in this document and assuming a ratio of chromium (VI) to chromium (III) of 1:6.

2. If there is a potential source for chromium (VI) or the data are statistically different (using a 95% confidence level) from background, additional sampling should be conducted to determine speciation. The species-specific data will then be compared to the trivalent and hexavalent chromium NMED screening levels presented in Table A-1.

5.3 Essential Nutrients

Essential nutrients are naturally occurring inorganic constituents that are essential for human health in trace amounts but may be toxic in high doses. Inorganics classified as essential nutrients that do not have published toxicity data [from the US EPA (2003) recommended hierarchy of sources] may be eliminated from further consideration in the risk assessments if they are detected in soil at concentrations that would not cause adverse effects to human health or the environment. Inorganics classified as essential nutrients that could be naturally occurring and do not have published toxicity data include: calcium, chloride, magnesium, phosphorous, potassium, and sodium.

Soil screening levels were calculated based upon dietary guidelines. The Institute of Medicine of the National Academy of Sciences has developed dietary guidelines for essential nutrients which include tolerable upper intake levels (ULs), recommended daily allowances (RDAs), and adequate intakes (AIs) (NAP, 2011 and 2006). A UL is the highest average daily intake level likely to pose no risk of adverse health effects to most individuals within the general population. As intake increases above the UL, the potential risk of adverse effects may increase. RDAs and AIs are the daily dietary intake levels of a nutrient considered to be sufficient within an age

group. Screening levels for essential nutrients were calculated for three different types of receptors (industrial worker, resident, and construction worker). The UL/RDA/AI was selected for industrial and construction workers based on an adult age group; for residents, levels were selected for a child age group.

The SSLs were derived using ULs and if an UL was not available, the more conservative of the available RDAs or AIs was utilized. Screening levels were calculated using Equation 61 and the toxicity data provided in Table 5-1 for ingestion of soil only. Screening levels are provided in Table A-1. Risk to essential nutrients may be tabulated separately from other chemicals, as toxicity is based on intake recommendations. Like noncarcinogens, a HQ or HI above 1.0 indicates excess risk may be present and additional evaluation may be required.

Table 5-1. Soil Screening Levels for Essential Nutrients

Essential Nutrient	Upper Level (UL) or Adequate Intake (AI), Child (mg/day)		Upper Level (UL) or Adequate Intake (AI), Adult (mg/day)	
Calcium	2500	UL	2000	UL
Chloride	2300	UL	3600	UL
Magnesium	65	UL	350	UL
Phosphorus	3000	UL	4000	UL
Potassium	3000	AI	4700	AI
Sodium	1500	UL	2300	UL

ULs and AIs taken from The National Academies Press (2011 and 2006, and United States Tolerable Upper Intake Levels (2014).

Equation 61
Calculation of SSLs for Essential Nutrients

$$SSL_{en} = \frac{DI \times AT}{IR \times CF \times EF \times ED}$$

Parameter	Definition (units)	Default
SSL_{en}	Soil screening level for essential nutrients (mg/kg)	Chemical-specific
DI	Daily intake (UL, RDA or AI) (mg/day)	Chemical-specific
AT	Averaging time (365 day/yr x ED)	Receptor-specific
IR	Ingestion rate (mg/day)	
	Industrial worker	100
	Resident (child)	200
	Construction worker	330
CF	Conversion factor (1E-06 kg/mg)	1E-06
EF	Exposure frequency (day/yr)	
	Industrial worker	225
	Resident (child)	350
	Construction worker	250
ED	Exposure duration (yr)	
	Industrial worker	25
	Resident (child)	6
	Construction worker	1

The maximum concentration ($conc_{en}$) of the essential nutrient should be compared via Equation 62 to the SSL provided in Table 5-1.

$$HQ_{en} = \left(\frac{conc_{en}}{SSL_{en}} \right) \times 1 \qquad \textbf{Equation 62}$$

If $conc_{en}$ for the site is below the soil SSL, resulting in an HQ of less than one, then exposure is not likely to cause adverse effects to receptors, and the inorganic constituent may be eliminated from further evaluation in the risk assessments. The risks from essential nutrients may be discussed separately from the overall HI for noncarcinogens.

5.4 Polyfluoroalkyl and Perfluoroalkyl Compounds (PFAS)

PFAS refers to polyfluoroalkyl and perfluoroalkyl compounds, which are synthetic chemicals that do not occur naturally. However, once released, they are persistent and mobile in the environment. These compounds (and other PFAS) repel oil, grease, and water and have been used in surface protection products such as carpet and clothing treatments, coatings for paper and cardboard packaging, flame retardation, surface friction reducers, and fire-fighting foams.

PFAS may be divided into two primary categories: polymer (or potential precursors) and non-polymer PFAS. The non-polymer PFAS consists of two major classes: polyfluoroalkyl and perfluoroalkyl substances. The polyfluorinated substances include precursor chemicals. The perfluorinated substances were selected as the focus within this NMED guidance because the non-polymer substances are more commonly detected in environmental media, they have been detected at investigation sites suspected of containing PFAS or are known sources for PFAS, preliminary federal guidance and screening levels are available, and have available methods for analysis.

Table 5-2 lists the most common PFAS that should be include in analytical suites. In addition, to the listed PFAS, four replacement chemicals, GenX, Adona, and F53b major and minor should be included in the analytical suite as appropriate based upon site history.

Table 5-2. PFAS Analyte List

Analytical Name	Acronym	CAS Number
Perfluorotetradecanoic acid	PFTeA	376-06-7
Perfluorotridecanoic acid	PFTriA	72629-94-8
Perfluorododecanoic acid	PFDoA	307-55-1
Perfluoroundecanoic acid	PFUnA	2058-94-8
Perfluorodecanoic acid	PFDA	335-76-2
Perfluorononanoic acid	PFNA	375-95-1
Perfluorooctanoic acid	PFOA	335-67-1
Perfluoroheptanoic acid	PFHpA	375-85-9
Perfluorohexanoic acid	PFHxA	307-24-4
Perfluoropentanoic acid	PFPeA	2706-90-3
Perfluorobutanoic acid	PFBA	375-22-4
Perfluorodecanesulfonic acid	PFDS	335-77-3
Perfluorononanesulfonic acid	PFNS	68259-12-1
Perfluorooctanesulfonic acid	PFOS	1763-23-1
Perfluoroheptanesulfonic acid	PFHpS	375-82-8
Perfluorohexanesulfonic acid	PFHxS	355-46-4
Perfluoropentanesulfonic acid	PFPeS	2706-91-4
Perfluorobutanesulfonic acid	PFBS	375-73-5
Perfluoroictabesylfonamide	PFOSA	754-91-6
Fluorotelomer sulphonic acid 8:2	FtS 8:2	39108-34-4
Fluorotelomer sulphonic acid 6:2	FtS 6:2	27619-97-2
Fluorotelomer sulphonic acid 4:2	FtS 4:2	757124-72-4
2-(N-Ethylperfluoroactanesulfonamido) acetic acid	N-EtFOSAA	2991-50-6
2-(N-Methylperfluoroactanesulfonamido) acetic acid	N-MeFOSAA	2355-31-9

Despite the large number of potentially present substances, toxicity studies have only been conducted on a few PFAS. While PFAS are a class of emerging compounds, there is much focus on these substances by State and Federal regulatory communities. It is anticipated that there will be changes and updates to preliminary screening levels as more data become available.

Under the Environmental Protection Agency's (US EPA) 2005 Guidelines for Carcinogen Risk Assessment, there is suggestive evidence of carcinogenic potential for PFOA. US EPA estimated a cancer slope factor of 0.07 per milligram per kilogram-day $(mg/kg\text{-}day)^{-1}$ based on testicular tumors. However, US EPA confirmed that the lifetime health advisory (HA) based on noncancer effects is protective of the cancer endpoint. (https://www.epa.gov/sites/production/files/2016-05/documents/pfoa_health_advisory_final-plain.pdf) As such, only non-carcinogenic screening levels for PFOA have been derived. There is insufficient data to assess carcinogenic risk to PFOS and PFHxS.

US EPA developed a Health Effects Support Document (HESD) for PFOA and another for PFOS to assist federal, state, tribal and local officials, and managers of drinking water systems in protecting public health when these chemicals are present in drinking water (US EPA 2016a, 2016b). The revised HESD for PFOA and the HESD for PFOS provide reference doses (RfDs) of 2×10^{-5} mg/(kg·day). While the RfDs were evaluated primarily to derive a basis for an HA for drinking water, they can be applied in determining preliminary soil screening levels for PFOA and PFOS. When evaluating intake via the soil exposure pathway, screening levels for PFHxS should be evaluated using a RfD of 2×10^{-5} mg/(kg·day) as discussed in Appendix E. Preliminary soil screening levels for PFBS can be derived from US EPA's chronic provisional RfD of 0.02 mg/(kg day) [US EPA 2014c]. A preliminary evaluation of soil exposures for PFNA can also be conducted based on its ATSDR provisional MSL of 3×10^{-6} mg/(kg day).

When evaluating groundwater data for ingestion of drinking water, the RfDs and MSLs for PFSF and PFNA are converted to screening level concentrations using the approach outlined for PFHxS in Appendix E. Note that in cases where more than one of the five longer-chain PFAS addressed herein are detected, the cumulative impact must be considered. For example, if only PFHxS is detected, PFHxS should be evaluated against a drinking water concentration of 0.04 µg/L. However, when PFHxS and any or all of PFOA, PFOS, PFBS, and PFNA are detected in drinking water, the sum of the concentrations of all detected longer-chain PFAs should be compared to 0.07 µg/L. For example, if PFOS, PFHxS, and PFNA are all detected, their concentrations should be summed, and the sum compared to 0.07 µg/L.
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Table 5-3. Preliminary Screening Levels for Select PFAS

Constituent	Residential (mg/kg) Noncancer	Industrial (mg/kg) Noncancer	Construction Worker (mg/kg) Noncancer	Tap Water (µg/L)
PFBS	1.56E+04	2.60E+05	7.08E+.4	7.00E-02
PFHxS	1.56E+00	2.60E+01	7.08E+00	7.00E-02[a]
PFNA	2.35E-01	3.89E+00	1.06E+00	7.00E-02
PFOA	1.56E+00	2.60E+01	7.08E+00	7.00E-02[a]
PFOS	1.56E+00	2.60E+01	7.08E+00	7.00E-02[a]

[a] When evaluating groundwater data for ingestion as drinking water, and only PFHxS is detected, PFHxS should be evaluated against the health advisory concentration of 0.07 µg/L. When PFHxS and other longer-chain PFAs are detected in drinking water, the sum of the concentrations of all longer-chain PFAs should be compared to 0.07 µg/L. For example, if PFOS, PFOA, and PFHxS are all detected in the drinking water/groundwater sample, their concentrations should be summed, and the sum compared to 0.07 µg/L.

NA – not available

Given the evolution of evaluating the toxicity for these compounds, it is recommended that any calculated risks/hazards also be qualitatively discussed in an uncertainty analysis.

6.0 TOTAL PETROLEUM HYDROCABONS (TPH)

6.1 TPH Fraction and Indicator Approach

Accurate characterization of TPH releases consisting of complex mixtures of organic compounds represents a major issue in evaluating the impact of these releases on human health. One approach that has been used calls for sampling of indicator compounds, such as benzene, toluene, ethylbenzene, and xylenes (BTEX) and a few PAHs, and ignoring the overall TPH level. This approach assumes that impacts to human health are largely due to exposure to the indicator compounds and as long as no risk is posed by the indicator chemicals, exposure to the other harmful components in the TPH Mixture does not pose a risk to human receptors. However, BTEX compounds are the most readily degraded components of petroleum products and may disappear well before the rest of the components comprising the TPH Mixture. In fact, the amount, and types of compounds in a petroleum hydrocarbon release differ widely depending on the type of product released and how the release is weathered. For example, low levels of BTEX are associated with diesel and fuel oils and the low percentages of BTEX components in diesel and fuel oils can make them difficult to measure accurately. Thus, addressing a diesel and/or

fuel oil release using only indicator compounds (i.e., BTEX and some PAHs) will not reliably account for the presence of heavier compounds in the released TPH Mixture (Ohio EPA, 2004).

The Total Petroleum Hydrocarbon Criteria Work Group (TPHCWG) has separated TPH fractions into groups based on carbon number and aliphatic versus aromatic nature. TPHCWG has also developed data tables of the physico-chemical property values and toxicity values for these TPH. Similarly, physico-chemical property values have been tabulated by the state of Texas [Figure: 30 TAC §350.73(e) of the Texas Risk Reduction Program (TRRP) rule]. This information allows for the calculation of leaching standards for TPH fractions. Thus, a class of chemicals, such as aromatics with carbon number equivalents between 8 and 10 (C8 to C10 aromatics) can be simulated using a single set of physico-chemical and toxicity values.

NMED assesses the potential impact to soil and groundwater from petroleum-based releases using an approach that combines the evaluation of indicator chemicals and the evaluation of TPH Fractions. This approach is similar to that described by the TPHCWG (TPGCWG, 1997c) and used in states like Ohio and Louisiana. The TPH fraction and indicator approach is based on the assessment of:

- Individual petroleum-related constituents (indicators) using constituent-specific toxicity criteria and physical/chemical properties, and
- TPH fractions using fraction-specific toxicity criteria and physical/chemical properties.

NMED has developed generic/default screening levels for the indicator chemicals and TPH hydrocarbon fractions associated with the petroleum products listed in Table 6-1 to screen releases of TPH hydrocarbon mixtures for protection of human health.

Table 6-1. TPH Compositional Assumptions[a] Used in Deriving Screening Levels

Petroleum Product	C11-C22 Aromatics	C9-C12 Aromatics	C5-C8 Aliphatics	C9-C18 Aliphatics	C19-C36 Aliphatics
Diesel #2/ new crankcase oil	60%			40%	0%
#3 and #6 Fuel Oil	70%			30%	0%
Kerosene and jet fuel	30%			70%	0%
Mineral oil dielectric fluid	20%			40%	40%
Unknown oil	100%			0%	0%
Waste Oil[b]	0%			0%	100%
Gasoline		43%	45%	12%	<1%

[a] MADEP, 2002
[b] Compositional assumption for waste oil developed by NMED is based on review of chromatographs of several types of waste oil.

6.2 Total Petroleum Hydrocarbons in Soil

In some instances, it may be practical to assess areas of soil contamination that are the result of releases of petroleum products using TPH analyses. TPH results may be used to delineate the

extent of petroleum-related contamination at these sites and ascertain if the residual level of petroleum products in soil represents an unacceptable risk to future users of the site. Petroleum hydrocarbons consist of complex mixtures of compounds, some of which are regulated constituents while others are not. In addition, the amount, and types of the constituent compounds in a petroleum hydrocarbon release differ widely depending on what type of product was spilled and how the spill has weathered. This variability makes it difficult to determine the toxicity of weathered petroleum products in soil solely from TPH results; however, these results can be used to approximate risk in some cases, depending upon the nature of the petroleum product, the release scenario, how well the site has been characterized, and the anticipated potential future land uses.

Site cleanup decisions cannot be based solely on the results of TPH sampling. Rather, the soil screening levels for TPH in Table 6-2 must be used in conjunction with the screening levels for individual petroleum-related contaminants listed in Table A-1 for soil exposure and threat to ground water. The TPH screening levels are not designed to be protective of exposure to these individual contaminants. Sites with petroleum product releases must be tested for VOCs, SVOCs, and if warranted, metals and PCBs, to determine if other potentially toxic constituents are present. Sites with unknown oil or waste oil releases must be tested for VOCs, SVOCs, metals, and PCBs.

The toxicity of petroleum hydrocarbons depends on their classification as aliphatic or aromatic and on their carbon number/molecular weight. Because TPH is essentially a summation of the three fractions, C11-C22 Aromatics, C9-C18 Aliphatics and C19-C36 Aliphatics, NMED derived TPH soil-screening values are based on reasonable assumptions about the composition of petroleum products commonly found at contaminated sites, as shown in Table 6-1.

TPH soil screening levels were calculated based on the noncarcinogenic toxicity of the hydrocarbon fractions as applicable to the ingestion and dermal exposure pathways, weighted according to the assumed composition of the petroleum product. Ceiling values that account for exposure pathways and factors that were not considered in the toxicity calculations, including public welfare concerns related to odors, were used where more conservative (MADEP 2014).

Table 6-2. TPH Soil Screening Levels

Petroleum Product	Residential Exposure (mg/kg)	Industrial/ Construction Worker Exposure (mg/kg)
Diesel #2/crankcase oil	1000	3000
#3 and #6 Fuel Oil	1000	3000
Kerosene and jet fuel	1000	3000
Mineral oil dielectric fluid	1800	3800
Unknown oil	1000	3800
Waste Oil	3000	5000
Gasoline	100	500

Mineral oil based hydraulic fluids can be evaluated for petroleum fraction toxicity using the screening guidelines from Table 6-3 specified for waste oil, because this type of hydraulic fluid is composed of approximately the same range of carbon fractions as waste oil. However, these hydraulic fluids often contain proprietary additives that may be significantly more toxic than the oil itself; these additives must be considered on a site- and product-specific basis (see ATSDR, 1997). Note that use of alternate screening levels requires prior written approval from the NMED.

The TPH soil screening levels are based solely on human health considerations related to direct soil exposure, not ecological risk considerations, protection of surface or ground water, or potential indoor air impacts from soil vapor. When evaluating TPH contaminated soils, the soil-to-groundwater pathway should be evaluated to determine the potential for hazardous constituents in the TPH Mixture to leach/migrate and impact groundwater.

Potential soil vapor impacts shall be evaluated for individual petroleum-related contaminants listed in Table A-1 and following the methodology in Section 6.4 of this guidance.

Note that facilities may be required to remediate to petroleum hydrocarbon concentrations that are lower than the concentrations specified by this approach if compliance with risk-based levels results in a visual or odor nuisance that compromises the aesthetic value and/or land use of the impacted site. For example, for a release of diesel fuel in an industrial area, where all the indicator constituents for petroleum-impacted soils are met and the TPH-diesel range organics (DRO) hydrocarbon concentration is less than or equal to the applicable screening levels, but a constant, objectionable odor is evident, excavation of the affected soils to aesthetically acceptable concentrations may be required. This new clean up goal would be governed by the aesthetic appearance and odor of the soil only, not a revised risk-based level.

6.3 Determination of Groundwater and Soil-to-Groundwater Screening Criteria for Petroleum Hydrocarbon Releases

The groundwater and soil-to-groundwater SL-SSLs addressed herein are based solely on human health considerations related to protection of ground water. Table 6-3 lists individual petroleum contaminants such as BTEX, PAH's, and methyl tertiary butyl ether (MTBE) associated with petroleum hydrocarbon releases. These individual compounds should be included in the evaluation of releases of TPHs to groundwater. Note that these individual contaminants and the associated TPH hydrocarbon fractions were identified as components of petroleum hydrocarbon releases in New Mexico and other states in US EPA Region 6 that could potentially serve as a source to groundwater.

Table 6-3. Indicator Compounds Associated with TPH Mixtures in New Mexico

Indicator Compounds
Benzene
Toluene
Ethylbenzene
Xylene
Acenaphthene
Anthracene
Benzo(a)pyrene
Chrysene
Dibenz(a,h)anthracene
Indeno(1,2,3-cd)pyrene
Benzo(k)fluoranthene
Benzo(b)fluoranthene
Benzo(a)anthracene
Fluoranthene
Fluorene
Naphthalene
Pyrene
Lead (inorganic)
Metals
Methyl tert butyl ether
Methyl ethyl ketone
Methyl isobutyl ketone

While the evaluation of individual petroleum contaminants is important, it does not evaluate the total potential impact on groundwater from a TPH release. BTEX compounds are the most readily degraded components of petroleum products and may disappear well before the rest of the TPH associated with a petroleum hydrocarbon source. Data on compositions of petroleum products taken from Volumes 2 and 3 of the TPHCWG report indicate that approximately 15 to 20 percent of most fuels is comprised of high weight aromatics (exclusive of BTEX or PAH). Evaluating the risk associated with diesel and fuel oil releases based solely on these low BTEX levels does not provide a reliable representation of the contribution of the heavier chemicals in TPH to groundwater risk. In addition, the components of BTEX are present at very low percentages in diesel and heating fuels making them difficult to measure accurately. A more detailed characterization of the TPH contamination is preferred over a characterization based solely on indicator chemicals or TPH fractions and the overly conservative risk assumptions needed to account for the uncertainties associated with the composition of a complex TPH Mixture released in the environment.

Due to their mobility and toxicity, C8 - C12 aromatics are the most likely fractions to impact ground water while aliphatics of equivalent carbon number are generally less mobile and less toxic and heavier weight aromatics tend to be less mobile (Ohio EPA, 2004). Thus, NMED has

calculated groundwater and SL-SSLs for the aliphatic and aromatic carbon fractions associated with TPH releases in New Mexico.

The evaluation of indicator chemicals is combined with the evaluation of aliphatic and aromatic hydrocarbon fractions to determine if a TPH release constitutes a threat to groundwater.

- Groundwater screening values for the TPH hydrocarbon fractions were calculated using a methodology similar to the Tier 1 methodology employed by MADEP and the TRRP Rule. Groundwater screening values for the TPH Mixtures identified in Table 6-1 are listed in Table 6-4.

- For the soil-to-groundwater target soil leachate concentrations for the petroleum hydrocarbon fractions (SSL_{TPH}), a single surrogate was conservatively assumed for each of the mixtures. For diesel, #3 and #6 fuels oils, and unknown oils, the SL-SSL_{TPH} values are based on C11-C22 aromatics. Kerosene and jet fuel levels were derived using C9-C18 aliphatics. Waste oil levels are based on C19-C36 aliphatics and gasoline levels were derived using C9-C12 aromatics.

- If the concentrations in groundwater exceed the groundwater screening levels for indicator chemicals (Table A-1) and/or TPH Mixtures presented in Table 6-4, the facility must evaluate the potential for risk to human health using the methodologies recommended by the New Mexico Ground Water Quality Bureau. Similarly, if the applicable values of SL-SSL_{TPH} calculated by NMED are exceeded by measured soil concentrations, the methodologies recommended by the New Mexico Ground Water Quality Bureau must be used to further evaluate the risk associated with the release of the TPH Mixture.

Table 6-4. Groundwater and SL-SSLs for TPH Mixtures

Petroleum Product	Groundwater Screening Level (µg/L)	SL-SSL_{TPH} DAF=1 (mg/kg)	SL-SSL_{TPH} DAF=20 (mg/kg)
Diesel #2/crankcase oil	1.67E+01	6.59E-01	1.32E+01
#3 and #6 Fuel Oil	2.09E+01	6.59E-01	1.32E+01
Kerosene and jet fuel	1.04E+01	1.23E-01	2.45E+02
Mineral oil dielectric fluid	1.81E+01	1.23E+01	2.45E+02
Unknown oil	8.58E+01	6.59E-01	1.32E+01
Waste Oil	6.02E+04	7.60E+02	1.52E+04
Gasoline	1.01E+01	2.47E-01	4.94E+00

6.4 TPH Vapor Intrusion Screening Levels

Calculation of VISLs for TPH mixtures was conducted using the methodologies outlined in Section 2.5.1. Weighted toxicity values were calculated based on the compositional assumptions if the carbon ranges listed in Table 6-1. The VISLs provided in Table 6-5 are conservative in that variability in specific composition of the mixtures, biodegradation, and attenuation will vary

site to site. If contamination of groundwater is present, collection of sub-slab soil vapor samples should be collected, which will minimize the uncertainty in fate and transport of petroleum vapors, over derivation of a groundwater based VISL (Brewer, *et al.*, 2013).

Table 6-5. TPH VISLs

Petroleum Product	Residential, Indoor Air (µg/m^3)	Residential, Soil Gas (µg/m^3)	Industrial, Indoor Air (µg/m^3)	Industrial, Soil Gas (µg/m^3)
Diesel #2/crankcase oil	2.61E+02	8.69E+03	1.23E+03	4.10E+04
#3 and #6 fuel oil	3.48E+02	1.16E+04	1.64E+03	5.46E+04
Kerosene and jet fuel	1.49E+02	4.97E+03	7.02E+02	2.34E+04
Mineral oil dielectric fluid	2.61E+02	8.69E+03	1.23E+03	4.10E+04
Unknown oil	NA	NA	NA	NA
Waste Oil	NA	NA	NA	NA
Gasoline	6.53E+03	2.17E+05	3.1E+04	1.02E+06

NA – not applicable

6.5 Application of the Groundwater and SL-SSLs at Facilities Potentially Impacted by Petroleum Hydrocarbon Releases

- Individual Petroleum-Related Contaminants. The individual petroleum-related contaminants associated with the release of a TPH Mixture should be identified and quantified as individual constituents using appropriate analytical methods. Note that acenaphthylene, benzo[j]fluorene, benzo[ghi]perylene, dibenz[ah]acridine, dibenz[aj]acridine, dibenzo[cg]carbazole, dibenz[ae] pyrene, dibenzo[ah]pyrene, dibenzo[ai]pyrene, 3-methylchloanthrene, and phenanthrene are included as analytes for some US EPA methods. However, it is not required that these constituents be evaluated as indicator chemicals as they are evaluated as components of the aromatic TPH fractions. For initial screening, the maximum concentration for each indicator chemical from the data set should be compared to the appropriate screening level.

- Hydrocarbon Fractions (or Hydrocarbon Mixtures). The TPH hydrocarbon fractions should be identified and quantified using an analytical method that has been proposed, reviewed, and approved by NMED in a project work plan. Based on the results, the weight percents (or mass fraction) of the TPH hydrocarbon fractions in the TPH Mixture should be determined and the screening values for the TPH Mixture most representative of the actual released mixture used to evaluate the potential for impacts to human health. The weight percent for each hydrocarbon fraction of the TPH Mixture should be determined by dividing the concentration of each fraction by the total concentration of the TPH Mixture.

- Select and analyze the sample with the highest TPH Mixture concentration from the source area(s) to compare to the identified screening level(s). The sample with the highest TPH concentration is needed to allow adequate quality assurance recovery results. The maximum TPH Mixture groundwater concentration should be compared to

the groundwater screening level for TPH Mixtures while the maximum soil concentration should be compared to the SL-SSL_{TPH} values for the mixture.

Typically, a single sample can be analyzed from each source area. However, for sites where different TPH Mixtures have been released, multiple TPH samples may need to be analyzed to identify appropriate screening values for each of the TPH source areas and ensure a comprehensive evaluation of potential impacts to human health. The concentration and weight percent of each boiling point range in each fraction should be determined and reported.

Any exceedance of a groundwater screening level or SL-SSL_{TPH} value for a TPH Mixture should be subjected to further evaluation, to include evaluation using the 95UCL. As noted above, that evaluation should be performed in accordance with the methodologies and recommendations of the NMED Ground Water Quality Bureau.

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APPENDIX A

NMED SOIL SCREENING LEVELS (SSLs)

Appendix A

State of New Mexico Soil Screening Levels

Table A-1 provides State of New Mexico Soil Screening Levels (SSLs), as developed by the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) and the Ground Water Quality Bureau Voluntary Remediation Program for chemicals most commonly associated with environmental releases within the state. These NMED SSLs are derived using default exposure parameter values (refer to Equations in Volume I) and chemical- and State of New Mexico-specific physical parameters (as presented in Tables B-1, B-2, and B-3 of Appendix B). These default values are assumed to be appropriately conservative in the face of uncertainty and are likely to be protective for the majority of site conditions relevant to soil exposures within New Mexico. Note that SSLs are derived using the appropriate equations provided in Volume I for noncarcinogens, carcinogens, mutagens, and for vinyl chloride and trichloroethylene.

However, the NMED SSLs are not necessarily protective of all known human exposure pathways, reasonable land uses or ecological threats. Thus, before applying NMED SSLs at a site, it is extremely important to compare the conceptual site model (CSM) with the assumptions upon which the NMED SSLs are predicated to ensure that the site conditions and exposure pathways match those used to develop the NMED SSLs. Table A-2 lists the exposure assumptions that were applied in the calculations of the NMED SSLs. If this comparison indicates that the site at issue is more complex than the corresponding SSL scenarios, or that there are significant exposure pathways not accounted for by the NMED SSLs, then the NMED SSLs are insufficient for use in a defensible assessment of the site. A more detailed site-specific approach will be necessary to evaluate the additional pathways or site conditions.

For reference, Table A-3 shows the various target soil leachate concentrations based on the tap water SSL, the NM groundwater protection criterion (20.6.2 New Mexico Administrative Code, NMAC), and the Federal Maximum Contaminant Level (MCL) for dilution attenuation factors (DAFs) of 1 and 20. The least conservative target leachate concentration to be used for the screening assessment is provided in Table A-1.

As noted above, separate NMED SSLs are presented for use in evaluating three discrete potential receptor populations: Residential, Industrial/Occupational, and Construction. Each NMED SSL considers incidental ingestion of soil, inhalation of volatiles from soil (limited to those chemicals noted as volatile organic compounds [VOCs] within Table B-2) and/or particulate emissions from impacted soil, and dermal contact with soil.

Generally, if a contaminant is detected at a level in soil exceeding the most relevant NMED SSL, and the site-specific CSM is in general agreement with the underlying assumptions upon which the NMED SSLs are predicated, this result indicates the potential for adverse human health effects to occur. Conversely, if no contaminants are detected above the most relevant NMED SSL, this tends to indicate to the user that environmental conditions may not necessitate remedial action of the surface soil or the vadose zone.

A detection above a NMED SSL does not indicate that unacceptable exposures are, in fact, occurring. The NMED SSLs are predicated on relatively conservative exposure assumptions and

an exceedance only tends to indicate the potential for adverse effects. The NMED SSLs do not account for additive exposures, whether for carcinogenic or noncarcinogenic endpoints. Section 5 of Volume I addresses a methodology by which an environmental manager may determine whether further site-evaluation is warranted, however, this methodology does not replace the need for defensible risk assessment where indicated. The SSLs also do not account for ingestion of homegrown produce/animals or the vapor intrusion pathway. If these or other exposure pathways are complete, additional analyses may be warranted.

The NMED SSLs address a basic subset of exposures fundamental to the widest array of environmentallyimpacted sites within the State of New Mexico. The NMED SSLs cannot address all relevant exposure pathways associated with all sites. The utility of the NMED SSLs depends heavily upon the understanding of site conditions as accurately reflected in the CSM and nature and extent of contamination determinations. Consideration of the NMED SSLs does not preclude the need for site-specific risk assessment in all instances.

Table A-4 provides State of New Mexico vapor intrusion screening levels (VISLs) for chemicals most commonly associated with environmental releases within the state and that are determined to be sufficiently volatile and toxic. A chemical is considered to be sufficiently volatile if its Henry's law constant is approximately 1 x 10^{-5} atm-m^3/mole or greater and its molecular weight is approximately 200 g/mole or less. A chemical is considered to be sufficiently toxic if the vapor concentration of the pure component poses an incremental lifetime cancer risk greater than 1E-05 or the noncancer hazard index is greater than 1.0. The NMED VISLs calculated for chemicals in Table A-4 are sufficiently volatile and toxic to be considered for the vapor intrusion pathway. The list of chemicals included in Table A-4 is <u>not</u> comprehensive of all potential volatile and toxic compounds that may be present in site media. If volatile and toxic constituents are detected in site media and are not listed in Table A-4, VISLs should be calculated following the methodologies herein and risks addressed. The NMED VISLs are derived using default exposure parameter values (refer to Equations in Volume I) and chemical-specific physical parameters (as presented in Tables B-1 and B-2 of Appendix B). These default values are assumed to be appropriately conservative in the face of uncertainty and are likely to be protective for the majority of site conditions relevant to vapor intrusion exposures within New Mexico.

Table A-1: NMED Soil Screening Levels

Chemical	CAS	Residential Soil, Cancer (mg/kg)	Residential Soil, Noncancer (mg/kg)	Industrial/ Occupational Soil, Cancer (mg/kg)	Industrial/ Occupational Soil, Noncancer (mg/kg)	Construction Worker Soil, Cancer (mg/kg)	Construction Worker Soil, Noncancer (mg/kg)	Tap Water, Cancer (µg/L)	Tap Water, Noncancer (µg/L)	Cw, DAF 20 (mg/kg)
Acenaphthene	83-32-9		3.48E+03		5.05E+04		1.51E+04		5.35E+02	8.25E+01
Acetaldehyde	75-07-0	3.38E+02	2.49E+02	1.64E+03	1.17E+03	7.61E+03	2.17E+02	2.55E+01	1.88E+01	6.58E-02
Acetone	67-64-1		6.63E+04		9.60E+05		2.42E+05		1.41E+04	4.98E+01
Acetophenone	98-86-2		7.82E+03		1.30E+05		3.54E+04		1.92E+03	9.64E+00
Acrolein	107-02-8		4.54E-01		2.16E+00		4.01E-01		4.15E-02	1.46E-04
Acrylonitrile	107-13-1	4.93E+00	3.99E+01	2.46E+01	1.90E+02	1.29E+02	3.52E+01	5.23E-01	4.15E+00	1.95E-03
Alachlor	15972-60-8	9.51E+01	6.16E+02	4.58E+02	9.16E+03	3.36E+03	2.69E+03	1.37E-01	1.86E+02	2.57E-02
Aldrin	309-00-2	3.11E-01	1.85E+00	1.50E+00	2.75E+01	1.09E+01	8.07E+00	1.98E-03	3.31E-02	4.88E-03
Aluminum	7429-90-5		7.80E+04		1.29E+06		4.14E+04		1.99E+04	5.97E+05
2-Amino-4,6-dinitrotoluene	35572-78-2		7.70E+00		1.27E+02		1.73E+01		1.93E+00	2.30E-02
4-Amino-2,6-dinitrotoluene	19406-51-0		7.64E+00		1.25E+02		1.73E+01		1.93E+00	2.30E-02
Ammonium Picrate	131-74-8		1.23E+02		1.83E+03		3.21E+01		3.95E+01	2.81E+00
Anthracene	120-12-7		1.74E+04		2.53E+05		7.53E+04		1.72E+03	8.51E+02
Antimony	7440-36-0		3.13E+01		5.19E+02		1.42E+02		7.26E+00	6.56E+00
Arsenic	7440-38-2	7.07E+00	1.30E+01	3.59E+01	2.08E+02	2.16E+02	4.12E+01	8.55E-01	3.55E+00	5.83E+00
Atrazine	1912-24-9	2.32E+01	2.16E+03	1.12E+02	3.21E+04	8.19E+02	9.42E+03	3.39E+00	7.02E+02	3.41E-02
Barium	7440-39-3		1.56E+04		2.55E+05		4.39E+03		3.28E+03	2.70E+03
Benzene	71-43-2	1.78E+01	1.14E+02	8.72E+01	7.29E+02	4.23E+02	1.42E+02	4.55E+00	3.32E+01	4.18E-02
Benzidine	92-87-5	5.18E-03	1.85E+02	1.12E-01	2.75E+03	8.12E-01	8.07E+02	1.09E-03	5.89E+01	4.27E-05
Benzo(a)anthracene	56-55-3	1.53E+00		3.23E+01		2.40E+02		1.20E-01		6.37E-01
Benzo(a)pyrene	50-32-8	1.12E+00	1.74E+01	2.36E+01	2.51E+02	1.73E+02	1.50E+01	2.51E-01	6.02E+00	4.42E+00
Benzo(b)fluoranthene	205-99-2	1.53E+00		3.23E+01		2.40E+02		3.43E-01		6.17E+00
Benzo(k)fluoranthene	207-08-9	1.53E+01		3.23E+02		2.31E+03		3.43E+00		6.05E+01
Beryllium	7440-41-7	6.44E+04	1.56E+02	3.13E+05	2.58E+03	2.71E+03	1.48E+02		1.24E+01	1.96E+02
a-BHC (a-Hexachlorocyclohexane, a-HCH)	319-84-6	8.45E-01	4.93E+02	4.07E+00	7.33E+03	2.97E+01	2.15E+03	6.93E-02	9.18E+01	6.08E-03
b-BHC (b-Hexachlorocyclohexane, b-HCH)	319-85-7	2.96E+00		1.43E+01		1.04E+02		2.43E-01		2.13E-02
t-BHC (t-Hexachlorocyclohexane, Lindane)	58-89-9	5.63E+00	2.12E+01	2.83E+01	3.34E+02	1.98E+02	9.43E+01	4.15E-01	3.60E+00	3.64E-02
1,1-Biphenyl	92-52-4	8.48E+02	3.91E+04	4.43E+03	6.49E+05	3.02E+04	1.77E+05	3.71E+01	8.34E-01	1.31E-01

Chemical	CAS	Residential Soil, Cancer (mg/kg)	Residential Soil, Noncancer (mg/kg)	Industrial/ Occupational Soil, Cancer (mg/kg)	Industrial/ Occupational Soil, Noncancer (mg/kg)	Construction Worker Soil, Cancer (mg/kg)	Construction Worker Soil, Noncancer (mg/kg)	Tap Water, Cancer (µg/L)	Tap Water, Noncancer (µg/L)	Cw, DAF 20 (mg/kg)
Bis(2-chloroethyl) ether	111-44-4	3.11E+00		1.57E+01		1.95E+00		1.37E-01		6.05E-04
Bis(2-chloroisopropyl) ether	108-60-1	9.93E+01		5.19E+02		3.54E+03		9.81E+00		4.75E-02
Bis(2-ethylhexyl)phthalate (di(2-ethylhexyl)phthalate, DEHP)	117-81-7	3.80E+02	1.23E+03	1.83E+03	1.83E+04	1.34E+04	5.38E+03	5.56E+01	4.01E+02	2.00E+02
Bis(chloromethyl) ether	542-88-1	2.08E-03		1.02E-02		4.81E-02		7.20E-04		3.00E-06
Boron	7440-42-8		1.56E+04		2.59E+05		5.14E+04		3.95E+03	2.51E+02
Bromodichloromethane	75-27-4	6.19E+00	1.56E+03	3.02E+01	2.60E+04	1.43E+02	7.08E+03	1.34E+00	3.77E+02	6.21E-03
Bromomethane	74-83-9		1.77E+01		9.45E+01		1.79E+01		7.54E+00	3.43E-02
1,3-Butadiene	106-99-0	9.48E-01	2.30E+00	4.63E+00	1.08E+01	2.21E+01	2.02E+00	7.08E-01	4.17E+00	8.13E-03
2-Butanone (Methyl ethyl ketone, MEK)	78-93-3		3.74E+04		4.11E+05		9.17E+04		5.56E+03	2.01E+01
tert-Butyl methyl ether (MTBE)	1634-04-4	9.75E+02	3.78E+04	4.82E+03	1.78E+05	2.42E+04	3.31E+04	1.43E+02	6.26E+03	5.53E-01
Cadmium	7440-43-9	8.59E+04	7.05E+01	4.17E+05	1.11E+03	3.61E+03	7.21E+01		6.24E+00	9.39E+00
Carbofuran	1563-66-2		3.08E+02		4.58E+03		1.35E+03		9.36E+01	5.91E-01
Carbon disulfide	75-15-0		1.55E+03		8.54E+03		1.62E+03		8.10E+02	4.42E+00
Carbon tetrachloride (Tetrachloromethane)	56-23-5	1.07E+01	1.44E+02	5.25E+01	1.02E+03	2.52E+02	2.02E+02	4.55E+00	4.92E+01	3.67E-02
Chlordane	12789-03-6	1.77E+01	3.53E+01	8.90E+01	5.56E+02	6.23E+02	1.53E+02	4.48E-01	1.27E+00	2.03E+00
2-Chloroacetophenone	532-27-4		1.72E+05		8.12E+05		2.81E+02			
2-Chloro-1,3-butadiene	126-99-8	1.75E-01	3.80E+01	8.48E-01	1.82E+02	3.95E+00	3.40E+01	1.87E-01	3.70E+01	1.97E-03
1-Chloro-1,1-difluoroethane	75-68-3		1.09E+05		5.15E+05		9.58E+04		1.04E+05	1.07E+03
Chlorobenzene (Monochlorobenzene)	108-90-7		3.78E+02		2.16E+03		4.12E+02		7.76E+01	1.08E+00
1-Chlorobutane	109-69-3		3.13E+03		5.19E+04		1.42E+04		6.31E+02	4.53E+00
Chlorodifluoromethane	75-45-6		1.02E+05		4.83E+05		8.98E+04		1.04E+05	8.55E+02
Chloroform (Trichloromethane)	67-66-3	5.90E+00	3.06E+02	2.87E+01	2.00E+03	1.34E+02	3.91E+02	2.29E+00	9.72E+01	1.09E-02
Chloromethane	74-87-3	4.11E+01	2.68E+02	2.01E+02	1.26E+03	9.56E+02	2.35E+02	2.03E+01	1.88E+02	9.52E-02
b-Chloronaphthalene	91-58-7		6.26E+03		1.04E+05		2.83E+04		7.33E+02	5.70E+01
o-Chloronitrobenzene	88-73-3	1.78E+01	1.84E+02	8.55E+01	2.72E+03	6.28E+02	8.39E+01	2.36E+00	5.49E+01	3.44E-02
p-Chloronitrobenzene	100-00-5	8.45E+02	6.16E+01	4.07E+03	9.16E+02	2.99E+04	2.57E+02	1.10E+02	1.79E+01	2.57E-01
2-Chlorophenol	95-57-8		3.91E+02		6.49E+03		1.77E+03		9.10E+01	1.15E+00
2-Chloropropane	75-29-6		2.86E+02		1.35E+03		2.51E+02		2.09E+02	1.26E+00
o-Chlorotoluene	95-49-8		1.56E+03		2.60E+04		7.08E+03		2.33E+02	3.56E+00

Chemical	CAS	Residential Soil, Cancer (mg/kg)	Residential Soil, Noncancer (mg/kg)	Industrial/ Occupational Soil, Cancer (mg/kg)	Industrial/ Occupational Soil, Noncancer (mg/kg)	Construction Worker Soil, Cancer (mg/kg)	Construction Worker Soil, Noncancer (mg/kg)	Tap Water, Cancer (µg/L)	Tap Water, Noncancer (µg/L)	Cw, DAF 20 (mg/kg)
Chromium III	16065-83-1		1.17E+05		1.95E+06		5.31E+05		1.36E+04	4.91E+08
Chromium VI	18540-29-9	3.05E+00	2.35E+02	7.21E+01	3.89E+03	6.69E+01	4.98E+02	5.01E-01	2.67E+01	1.92E-01
Chromium (Total)		9.66E+01	4.52E+04	5.05E+02	3.14E+05	4.68E+02	1.34E+02	5.70E+00	1.17E+04	2.05E+05
Chrysene	218-01-9	1.53E+02		3.23E+03		2.31E+04		3.43E+01		1.86E+02
Cobalt	7440-48-4	1.72E+04	2.34E+01	8.34E+04	3.88E+02	7.22E+02	3.67E+01		5.98E+00	5.40E+00
Copper	7440-50-8		3.13E+03		5.19E+04		1.42E+04		7.90E+02	9.15E+02
Crotonaldehyde	123-73-9	3.66E+00	7.82E+01	1.91E+01	1.30E+03	1.30E+02	3.54E+02	4.04E-01	1.98E+01	1.42E-03
Cumene (isopropylbenzene)	98-82-8		2.36E+03		1.42E+04		2.74E+03		4.47E+02	1.14E+01
Cyanide	57-12-5		1.12E+01		6.33E+01		1.21E+01		1.46E+00	7.13E-01
Cyanogen	460-19-5		7.82E+01		1.30E+03		3.54E+02		1.99E+01	8.01E-02
Cyanogen bromide	506-68-3		7.04E+03		1.17E+05		3.19E+04		1.80E+03	1.06E+01
Cyanogen chloride	506-77-4		3.91E+03		6.49E+04		1.77E+04		9.99E+02	5.88E+00
Cyclohexane	110-83-8		3.91E+02		6.49E+03		1.77E+03		6.86E+01	1.49E+00
DDD	72-54-8	2.22E+01		1.07E+02		7.78E+02		3.17E-01		1.12E+00
DDE	72-55-9	1.57E+01		7.55E+01		5.49E+02		4.62E-01		1.63E+00
DDT	50-29-3	1.87E+01	3.62E+01	9.50E+01	5.77E+02	6.59E+02	1.62E+02	2.29E+00	1.00E+01	1.16E+01
Dibenz(a,h)anthracene	53-70-3	1.53E-01		3.23E+00		2.40E+01		3.43E-02		1.97E+00
1,2-Dibromo-3-chloropropane	96-12-8	8.58E-02	5.88E+00	1.18E+00	4.11E+01	5.53E+00	8.29E+00	3.34E-03	3.72E-01	1.39E-03
Dibromochloromethane	124-48-1	1.39E+01	1.23E+03	6.74E+01	1.83E+04	3.40E+02	5.38E+03	1.68E+00	3.78E+02	7.55E-03
1,2-Dibromoethane (Ethylene dibromide, EDB)	106-93-4	6.72E-01	1.35E+02	3.31E+00	7.38E+02	1.63E+01	1.40E+02	7.47E-02	1.69E+01	3.52E-04
1,4-Dichloro-2-butene	764-41-0	1.15E-01		5.58E-01		2.59E+00		1.34E-02		9.99E-05
1,2-Dichlorobenzene (ortho-Dichlorobenzene)	95-50-1		2.15E+03		1.30E+04		2.50E+03		3.02E+02	9.08E+00
1,4-Dichlorobenzene (para-Dichlorobenzene)	106-46-7	1.29E+03	5.48E+03	6.73E+03	9.08E+04	4.59E+04	2.48E+04	4.82E+00	5.63E+02	1.12E+00
3,3-Dichlorobenzidine	91-94-1	1.18E+01		5.70E+01		4.10E+02		1.25E+00		1.24E-01
Dichlorodifluoromethane (Fluorocarbon-12)	75-71-8		1.82E+02		8.65E+02		1.61E+02		1.97E+02	7.23E+00
1,1-Dichloroethane (1,1-DCA)	75-34-3	7.86E+01	1.56E+04	3.83E+02	2.60E+05	1.82E+03	7.08E+04	2.75E+01	3.74E+03	1.36E-01
1,2-Dichloroethane (Ethylene dichloride, EDC)	107-06-2	8.32E+00	5.56E+01	4.07E+01	2.86E+02	1.95E+02	5.38E+01	1.71E+00	1.30E+01	2.38E-02
cis-1,2-Dichloroethene (cis-1,2-DCE)	156-59-2		1.56E+02		2.60E+03		7.08E+02		3.65E+01	3.52E-01
trans-1,2-Dichloroethene (trans-1,2-DCE)	156-60-5		2.10E+02		1.10E+03		2.06E+02		6.79E+01	5.03E-01

Chemical	CAS	Residential Soil, Cancer (mg/kg)	Residential Soil, Noncancer (mg/kg)	Industrial/ Occupational Soil, Cancer (mg/kg)	Industrial/ Occupational Soil, Noncancer (mg/kg)	Construction Worker Soil, Cancer (mg/kg)	Construction Worker Soil, Noncancer (mg/kg)	Tap Water, Cancer (µg/L)	Tap Water, Noncancer (µg/L)	Cw, DAF 20 (mg/kg)
1,1-Dichloroethene (1,1-DCE)	75-35-4		4.40E+02		2.26E+03		4.24E+02		2.84E+02	1.95E+00
2,4-Dichlorophenol	120-83-2		1.85E+02		2.75E+03		8.07E+02		4.53E+01	8.25E-01
1,2-Dichloropropane (propylene dichloride, PDC)	78-87-5	1.78E+01	2.90E+01	8.68E+01	1.37E+02	4.15E+02	2.54E+01	4.38E+00	8.30E+00	2.77E-02
1,3-Dichloropropene	542-75-6	2.93E+01	1.41E+02	1.46E+02	6.95E+02	7.81E+02	1.30E+02	4.71E+00	3.88E+01	2.81E-02
Dicyclopentadiene	77-73-6		6.26E+03		1.04E+05		2.83E+04		6.25E-01	3.42E-02
Dieldrin	60-57-1	3.33E-01	3.08E+00	1.60E+00	4.58E+01	1.17E+01	1.35E+01	1.75E-02	3.72E-01	1.06E-02
Diethyl phthalate (DEP)	84-66-2		4.93E+04		7.33E+05		2.15E+05		1.48E+04	9.79E+01
Di-n-butyl phthalate (Dibutyl phthalate)	84-74-2		6.16E+03		9.16E+04		2.69E+04		8.85E+02	3.38E+01
2,4-Dimethylphenol	105-67-9		1.23E+03		1.83E+04		5.38E+03		3.54E+02	6.45E+00
Dimethyl phthalate (DMP, Phthalic Acid)	100-21-0		6.16E+04		9.16E+05		2.69E+05		6.12E+02	3.57E+00
4,6-Dinitro-o-cresol	534-52-1		4.93E+00		7.33E+01		2.15E+01		1.52E+00	3.98E-02
2,4-Dinitrophenol	51-28-5		1.23E+02		1.83E+03		5.38E+02		3.87E+01	6.69E-01
2,4-Dinitrotoluene (2,4-DNT)	121-14-2	1.71E+01	1.23E+02	8.23E+01	1.82E+03	6.00E+02	5.36E+02	2.37E+00	3.80E+01	4.92E-02
2,6-Dintitrotoluene (2,6-DNT)	606-20-2	3.56E+00	1.85E+01	1.72E+01	2.76E+02	1.65E+02	8.09E+01	4.85E-01	5.64E+00	1.02E-02
2,4/2,6-Dintrotoluene Mixture	25321-14-6	7.83E+00		3.77E+01		2.77E+02		1.06E+00		2.24E-02
1,4-Dioxane	123-91-1	5.33E+01	1.85E+03	2.57E+02	2.75E+04	1.88E+03	7.85E+03	4.59E+00	5.67E+01	1.63E-02
1,2-Diphenylhydrazine	122-66-7	6.66E+00		3.21E+01		2.34E+02		7.80E-01		3.79E-02
Endosulfan	115-29-7		3.70E+02		5.50E+03		1.61E+03		9.87E+01	2.04E+01
Endrin	72-20-8		1.85E+01		2.75E+02		8.07E+01		2.23E+00	1.35E+00
Epichlorohydrin	106-89-8	4.22E+02	4.27E+01	2.14E+03	2.15E+02	1.22E+04	4.02E+01	2.92E+01	2.05E+00	7.72E-03
Ethyl acetate	141-78-6		1.82E+03		8.75E+03		1.63E+03		1.45E+02	5.28E-01
Ethyl acrylate	140-88-5	1.45E+02		7.57E+02		5.16E+03		1.57E+01		5.98E-02
Ethyl chloride	75-00-3		1.90E+04		8.95E+04		1.66E+04		2.09E+04	1.07E+02
Ethyl ether	60-29-7		1.56E+04		2.60E+05		7.08E+04		3.93E+03	1.52E+01
Ethyl methacrylate	97-63-2		2.73E+03		1.78E+04		3.48E+03		4.55E+02	1.83E+00
Ethylbenzene	100-41-4	7.51E+01	3.93E+03	3.68E+02	2.90E+04	1.77E+03	5.80E+03	1.50E+01	8.00E+02	1.23E+01
Ethylene oxide	75-21-8	1.88E-01	6.35E+02	9.15E-01	2.99E+03	4.26E+00	5.55E+02	1.86E-02	6.26E+01	6.65E-05
Fluoranthene	206-44-0		2.32E+03		3.37E+04		1.00E+04		8.02E+02	1.34E+03
Fluorene	86-73-7		2.32E+03		3.37E+04		1.00E+04		2.88E+02	8.00E+01

Chemical	CAS	Residential Soil, Cancer (mg/kg)	Residential Soil, Noncancer (mg/kg)	Industrial/ Occupational Soil, Cancer (mg/kg)	Industrial/ Occupational Soil, Noncancer (mg/kg)	Construction Worker Soil, Cancer (mg/kg)	Construction Worker Soil, Noncancer (mg/kg)	Tap Water, Cancer (µg/L)	Tap Water, Noncancer (µg/L)	Cw, DAF 20 (mg/kg)
Fluoride	7782-41-4		4.69E+03		7.78E+04		1.81E+04		1.18E+03	1.20E+04
Furan	110-00-9		7.24E+01		1.15E+03		3.54E+02		1.92E+01	1.22E-01
Glyphosate	1071-83-6		6.16E+03		9.16E+04		2.69E+04		2.01E+03	1.33E+02
Heptachlor	76-44-8	1.18E+00	3.08E+01	5.70E+00	4.58E+02	4.15E+01	1.35E+02	2.21E-02	2.72E+00	4.97E-01
Hexachlorobenzene	118-74-1	3.33E+00	4.93E+01	1.60E+01	7.33E+02	1.17E+02	2.15E+02	9.76E-02	1.60E+01	1.89E-01
Hexachloro-1,3-butadiene	87-68-3	6.83E+01	6.16E+01	5.21E+01	9.16E+02	2.40E+03	2.69E+02	1.39E+00	6.30E+00	4.13E-02
Hexachlorocyclopentadiene	77-47-4		2.30E+00		5.49E+03		8.67E+02		4.11E-01	2.40E+00
Hexachloroethane	67-72-1	1.33E+02	4.31E+01	6.41E+02	6.41E+02	4.67E+03	1.88E+02	3.28E+00	6.14E+00	3.20E-02
n-Hexane	110-54-3		6.15E+02		3.20E+03		6.03E+02		3.19E+02	5.57E+01
HMX (Octrahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)	2691-41-0		3.85E+03		6.33E+04		1.74E+04		1.00E+03	1.94E+01
Hydrazine anhydride	302-01-2	1.78E+00	1.81E+00	1.36E+00	8.54E+00	5.99E+01	2.81E+02	1.10E-02	6.26E-02	3.81E-05
Hydrogen cyanide	74-90-8		1.02E+01		5.72E+01		1.09E+01		1.46E+00	5.22E-03
Indeno(1,2,3-c,d)pyrene	193-39-5	1.53E+00		3.23E+01		2.40E+02		3.43E-01		2.01E+01
Iron	7439-89-6		5.48E+04		9.08E+05		2.48E+05		1.38E+04	6.96E+03
Isobutanol (Isobutyl alcohol)	78-83-1		1.85E+04		2.75E+05		8.07E+04		5.91E+03	2.10E+01
Isophorone	78-59-1	5.61E+03	1.23E+04	2.70E+04	1.83E+05	1.98E+05	5.37E+04	7.81E+02	3.83E+03	4.23E+00
Lead	7439-92-1									2.70E+02
Lead (tetraethyl-)	78-00-2		6.16E-03		9.16E-02		3.54E-02		1.24E-03	9.41E-05
Maleic hydrazide	123-33-1		3.08E+04		4.58E+05		1.35E+05		1.00E+04	3.57E+01
Manganese	7439-96-5		1.05E+04		1.60E+05		4.64E+02		2.02E+03	2.63E+03
Mercury (elemental)	7439-97-6		2.38E+01		1.12E+02		2.07E+01		6.26E-01	2.09E+00
Mercury (methyl)	22967-92-6		7.82E+00		1.30E+02		3.54E+01		1.96E+00	7.58E-03
Mercury (salts)	7487-94-7		2.35E+01		3.89E+02		7.71E+01		4.92E+00	5.13E+00
Methacrylonitrile	126-98-7		7.70E+00		1.23E+02		3.28E+01		1.91E+00	7.43E-03
Methomyl	16752-77-5		1.54E+03		2.29E+04		6.73E+03		4.98E+02	1.87E+00
Methyl acetate	79-20-9		7.82E+04		1.30E+06		3.54E+05		1.99E+04	7.11E+01
Methyl acrylate	96-33-3		3.50E+02		1.85E+03		3.48E+02		3.90E+01	1.43E-01
Methyl isobutyl ketone	108-10-1		5.81E+03		8.16E+04		2.02E+04		1.24E+03	4.80E+00
Methyl methacrylate	80-62-6		1.11E+04		5.65E+04		1.06E+04		1.39E+03	5.22E+00

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Methyl styrene (alpha)	98-83-9		5.48E+03		9.08E+04		2.48E+04		7.65E+02	1.89E+01
Methyl styrene (mixture)	25013-15-4		2.73E+02		2.20E+03		4.49E+02		3.73E+01	9.40E-01
Methylcyclohexane	108-87-2		5.50E+03		2.59E+04		4.82E+03		6.26E+03	3.16E+02
Methylene bromide (Dibromomethane)	74-95-3		5.79E+01		2.88E+02		5.39E+01		8.00E+00	3.35E-02
Methylene chloride (Dichloromethane)	75-09-2	7.66E+02	4.09E+02	1.44E+04	5.13E+03	8.96E+04	1.21E+03	1.18E+02	1.06E+02	4.71E-01
1-Methylnaphthalene	90-12-0	1.72E+02	4.06E+03	8.13E+02	5.89E+04	6.06E+03	1.76E+04	1.14E+01	6.11E+02	8.93E-01
2-Methylnaphthalene	91-57-6		2.32E+02		3.37E+03		1.00E+03		3.51E+01	2.76E+00
Molybdenum	7439-98-7		3.91E+02		6.49E+03		1.62E+03		9.87E+01	3.98E+01
Naphthalene	91-20-3	2.26E+01	1.62E+02	1.34E+02	8.43E+02	6.33E+02	1.59E+02	1.17E+00	6.11E+00	5.83E-02
Nickel	7440-02-0	5.95E+05	1.56E+03	2.89E+06	2.57E+04	2.50E+04	7.53E+02		3.72E+02	4.85E+02
Nitrate	14797-55-8		1.25E+05		2.08E+06		5.66E+05		3.16E+04	4.25E+02
Nitrite	14797-65-0		7.82E+03		1.30E+05		3.54E+04		1.97E+03	2.66E+01
Nitrobenzene	98-95-3	6.04E+01	1.31E+02	2.93E+02	1.54E+03	1.35E+03	3.53E+02	1.40E+00	1.25E+01	1.44E-02
Nitroglycerin	55-63-0	3.13E+02	6.16E+00	1.51E+03	9.16E+01	1.11E+04	2.69E+01	4.47E+01	1.96E+00	1.36E-02
p-Nitrophenol										
2-Nitropropane	79-46-9	1.34E+00		6.52E+00		3.03E+01		9.68E-02		9.94E-06
N-Nitrosodiethylamine	55-18-5	7.94E-03		1.71E-01		1.25E+00		1.67E-03		9.94E-06
N-Nitrosodimethylamine	62-75-9	2.34E-02	4.93E-01	5.03E-01	7.33E+00	3.66E+00	2.14E+00	4.91E-03	1.60E-01	2.04E-05
N-Nitrosodi-*n*-butylamine	924-16-3	7.81E-01		3.77E+00		2.46E+01		2.73E-02		8.42E-04
N-Nitrosodiphenylamine	86-30-6	1.09E+03		5.24E+03		3.79E+04		1.22E+02		1.00E+01
N-Nitrosopyrrolidine	930-55-2	2.54E+00		1.22E+01		8.89E+01		3.70E-01		2.30E-03
m-Nitrotoluene	99-08-1		6.16E+00		9.16E+01		2.69E+01		1.74E+00	2.50E-02
o-Nitrotoluene	88-72-2	3.16E+01	7.04E+01	1.65E+02	1.17E+03	1.13E+03	3.19E+02	3.14E+00	1.61E+01	4.58E-02
p-Nitrotoluene	99-99-0	3.33E+02	2.47E+02	1.60E+03	3.67E+03	1.18E+04	1.08E+03	4.27E+01	7.07E+01	6.13E-01
Pentachlorobenzene	608-93-5		4.93E+01		7.33E+02		2.15E+02		3.07E+00	3.52E-01
Pentachlorophenol (PCP)	87-86-5	9.85E+00	2.34E+02	4.45E+01	3.18E+03	3.46E+02	9.89E+02	4.13E-01	2.21E+01	1.52E-01
Perchlorate	14797-73-0		5.48E+01		9.08E+02		2.48E+02		1.38E+01	1.17E-01
Polyfluoroalkyl and Perfluoroalkyl Compounds (PFAS) - Refer to Section 5.3 on use of these preliminary screening levels										
Perfluorohexane sulfonic acid (PFHxS)	335-46-4		1.56E+00		2.60E+01		7.08E+00		7.00E-02	
Perfluorooctane sulfonate (PFO, PFOS)	2795-39-3		1.56E+00		2.60E+01		7.08E+00		7.00E-02	

Chemical	CAS	Residential Soil, Cancer (mg/kg)	Residential Soil, Noncancer (mg/kg)	Industrial/ Occupational Soil, Cancer (mg/kg)	Industrial/ Occupational Soil, Noncancer (mg/kg)	Construction Worker Soil, Cancer (mg/kg)	Construction Worker Soil, Noncancer (mg/kg)	Tap Water, Cancer (µg/L)	Tap Water, Noncancer (µg/L)	Cw, DAF 20 (mg/kg)
Perfluorooctanoic acid (PFOA)	335-67-1		1.56E+00		2.60E+01		7.08E+00		7.00E-02	
Perfluorobutane sulfonate (PFBS)	375-73-5		1.56E+04		2.60E+05		7.08E+04		7.00E-02	8.59E+01
Perfluorononanoic acid (PFNA)	375-95-1		2.35E-01		3.89E+00		1.06E+00		7.00E-02	5.23E+01
Phenanthrene	85-01-8		1.74E+03		2.53E+04		7.53E+03		1.70E+02	8.59E+01
Phenol	108-95-2		1.85E+04		2.75E+05		7.74E+04		5.76E+03	5.23E+01
Picric Acid (2,4,6-Trinitrophenol)	88-89-1		1.23E+02		1.83E+03		5.38E+02		3.95E+01	2.81E+00
Polychlorinatedbiphenyls (PCBs)										
Aroclor 1016	12674-11-2	6.96E+01	3.98E+00	3.04E+02	5.74E+01	2.44E+03	1.72E+01	2.24E+00	1.40E+00	2.01E+00
Aroclor 1221	11104-28-2	1.81E+00		8.57E+00		5.53E+01		5.61E-02		1.43E-02
Aroclor 1232	11141-16-5	1.86E+00		8.82E+00		5.76E+01		5.61E-02		1.43E-02
Aroclor 1242	53469-21-9	2.43E+00		1.09E+01		8.53E+01		7.86E-02		1.84E-01
Aroclor 1248	12672-29-6	2.43E+00		1.07E+01		8.53E+01		7.86E-02		1.81E-01
Aroclor 1254	11097-69-1	2.43E+00	1.14E+00	1.10E+01	1.64E+01	8.53E+01	4.91E+00	7.86E-02	4.01E-01	3.08E-01
Aroclor 1260	11096-82-5	2.43E+00		1.11E+01		8.53E+01		7.86E-02		8.25E-01
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	35065-30-6	3.75E-01	3.98E-01	1.77E+00	5.74E+00	1.31E+01	1.72E+00	5.99E-02	1.40E-01	6.42E-01
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	35065-29-3	3.75E+00	3.98E+00	1.77E+01	5.74E+01	1.31E+02	1.72E+01	5.99E-01	1.40E+00	6.29E+00
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	39635-31-9	1.25E+00	1.33E+00	5.81E+00	1.91E+01	4.37E+01	5.73E+00	3.95E-02	4.01E-01	4.15E-01
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	52663-72-6	1.25E+00	1.33E+00	5.78E+00	1.91E+01	4.37E+01	5.73E+00	3.95E-02	4.01E-01	2.48E-01
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	69782-90-7	1.25E+00	1.33E+00	5.78E+00	1.91E+01	4.37E+01	5.73E+00	3.95E-02	4.01E-01	2.53E-01
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	38380-08-4	1.25E+00	1.33E+00	5.75E+00	1.91E+01	4.37E+01	5.73E+00	3.95E-02	4.01E-01	2.53E-01
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	32774-16-6	1.25E-03	1.33E-03	5.78E-03	1.91E-02	4.37E-02	5.73E-03	3.95E-05	4.01E-04	2.48E-04
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	65510-44-3	1.25E+00	1.33E+00	5.73E+00	1.91E+01	4.37E+01	5.73E+00	3.95E-02	4.01E-01	1.55E-01
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	31508-00-6	1.25E+00	1.32E+00	5.64E+00	1.91E+01	4.37E+01	5.73E+00	3.95E-02	4.01E-01	1.52E-01
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	32598-14-4	1.25E+00	1.32E+00	5.64E+00	1.91E+01	4.37E+01	5.73E+00	3.95E-02	4.01E-01	1.55E-01
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	74472-37-0	1.25E+00	1.33E+00	5.73E+00	1.91E+01	4.37E+01	5.73E+00	3.95E-02	4.01E-01	1.55E-01
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	57465-28-8	3.75E-04	3.98E-04	1.72E-03	5.74E-03	1.31E-02	1.72E-03	1.19E-05	1.20E-04	4.55E-05
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	32598-13-3	3.75E-01	3.98E-01	1.77E+00	5.74E+00	1.31E+01	1.72E+00	5.99E-02	1.40E-01	1.41E-01
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	70362-50-4	1.25E-01	1.32E-01	5.66E-01	1.91E+00	4.37E+00	5.73E-01	3.95E-03	4.01E-02	9.27E-03
Prometon	1610-18-0		9.25E+02		1.37E+04		4.04E+03		2.50E+02	1.92E+00
Propylene oxide	75-56-9	2.56E+01	9.14E+02	1.33E+02	4.31E+03	8.55E+02	7.99E+02	2.66E+00	6.26E+01	9.65E-03

Chemical	CAS	Residential Soil, Cancer (mg/kg)	Residential Soil, Noncancer (mg/kg)	Industrial/ Occupational Soil, Cancer (mg/kg)	Industrial/ Occupational Soil, Noncancer (mg/kg)	Construction Worker Soil, Cancer (mg/kg)	Construction Worker Soil, Noncancer (mg/kg)	Tap Water, Cancer (µg/L)	Tap Water, Noncancer (µg/L)	Cw, DAF 20 (mg/kg)
Pyrene	129-00-0		1.74E+03		2.53E+04		7.53E+03		1.17E+02	1.92E+02
RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine	121-82-4	8.31E+01	3.01E+02	4.28E+02	4.89E+03	2.96E+03	1.35E+03	9.66E+00	7.96E+01	5.93E-02
Selenium	7782-49-2		3.91E+02		6.49E+03		1.75E+03		9.87E+01	1.02E+01
Silver	7440-22-4		3.91E+02		6.49E+03		1.77E+03		8.12E+01	1.38E+01
Simazine	122-34-9	4.44E+01	3.08E+02	2.14E+02	4.58E+03	1.57E+03	1.35E+03	6.07E+00	9.40E+01	4.83E-02
Strontium	7440-24-6		4.69E+04		7.79E+05		2.12E+05		1.18E+04	8.33E+03
Styrene (Ethenylbenzene)	100-42-5		7.26E+03		5.13E+04		1.02E+04		1.21E+03	2.06E+01
Sulfolane (thiolane 1,1 dioxide)	126-33-0		6.16E+01		9.16E+02		2.65E+02		2.00E+01	7.49E-02
2,3,7,8-TCDD	1746-01-6	4.90E-05	5.06E-05	2.38E-04	8.08E-04	1.72E-03	2.26E-04	1.19E-06	1.20E-05	2.24E-04
2,3,7,8-TCDF	51207-31-9	4.90E-04		2.43E-03		1.72E-02		1.84E-06		7.69E-06
1,2,4,5-Tetrachlorobenzene	95-94-3		1.85E+01		2.75E+02		8.07E+01		1.66E+00	1.17E-01
1,1,1,2-Tetrachloroethane	630-20-6	2.81E+01	2.35E+03	1.37E+02	3.89E+04	6.59E+02	1.06E+04	5.74E+00	4.77E+02	3.60E-02
1,1,2,2-Tetrachloroethane	79-34-5	7.98E+00	1.56E+03	3.94E+01	2.60E+04	1.97E+02	7.08E+03	7.57E-01	3.60E+02	4.81E-03
Tetrachloroethene (Perchloroethylene, PCE)	127-18-4	3.37E+02	1.11E+02	1.65E+03	6.29E+02	7.91E+03	1.20E+02	1.13E+02	4.03E+01	3.21E-01
N,N,N',N''-tetramethylphosphoramide (TMPA)	16853-36-4		6.16E+00		9.16E+01		2.69E+01		2.00E+00	6.95E-03
Tetryl (Trinitrophenylmethylnitramine)	479-45-8		1.56E+02		2.59E+03		7.06E+02		3.94E+01	5.59E+00
Thallium	7440-28-0		7.82E-01		1.30E+01		3.54E+00		1.97E-01	2.85E+00
Toluene (Methylbenzene)	108-88-3		5.23E+03		6.13E+04		1.40E+04		1.09E+03	1.21E+01
Toxaphene	8001-35-2	4.84E+00		2.33E+01		1.70E+02		1.58E-01		6.96E+00
Tribromomethane (Bromoform)	75-25-2	6.74E+02	1.23E+03	1.76E+03	1.83E+04	2.37E+04	5.38E+03	3.29E+01	3.76E+02	1.47E-01
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1		5.08E+04		2.43E+05		4.53E+04		5.50E+04	3.20E+03
1,2,4-Trichlorobenzene	120-82-1	2.40E+02	8.29E+01	1.25E+03	4.23E+02	8.54E+03	7.91E+01	1.15E+01	3.98E+00	3.10E+00
1,1,1-Trichloroethane (TCA)	71-55-6		1.44E+04		7.25E+04		1.36E+04		8.00E+03	5.11E+01
1,1,2-Trichloroethane (1,2,-TCA)	79-00-5	1.88E+01	2.61E+00	9.21E+01	1.24E+01	4.30E+03	2.30E+00	2.75E+00	4.15E-01	2.68E-02
Trichloroethylene (trichloroethene, TCE)	79-01-6	1.55E+01	6.77E+00	1.12E+02	3.65E+01	5.37E+03	6.90E+00	2.59E+00	2.82E+00	3.10E-02
Trichlorofluoromethane (Fluorocarbon-11)	75-69-4		1.23E+03		6.03E+03		1.13E+03		1.14E+03	1.57E+01
2,4,5-Trichlorophenol	95-95-4		6.16E+03		9.16E+04		2.69E+04		1.17E+03	6.62E+01
2,4,6-Trichlorophenol	88-06-2	4.84E+02	6.16E+01	2.33E+03	9.16E+02	1.70E+04	2.69E+02	4.11E+01	1.19E+01	6.74E-01
1,1,2-Trichloropropane	598-77-6		3.91E+02		6.49E+03		1.77E+03		8.81E+01	5.59E-01
1,2,3-Trichloropropane	96-18-4	5.10E-02	7.09E+00	1.21E+00	3.40E+01	8.26E+00	6.31E+00	8.35E-03	6.20E-01	5.82E-05

Chemical	CAS	Residential Soil, Cancer (mg/kg)	Residential Soil, Noncancer (mg/kg)	Industrial/ Occupational Soil, Cancer (mg/kg)	Industrial/ Occupational Soil, Noncancer (mg/kg)	Construction Worker Soil, Cancer (mg/kg)	Construction Worker Soil, Noncancer (mg/kg)	Tap Water, Cancer (µg/L)	Tap Water, Noncancer (µg/L)	Cw, DAF 20 (mg/kg)
Triethylamine	121-44-8		1.93E+02		9.09E+02		1.69E+02		1.46E+01	7.31E-02
2,4,6-Trinitrotoluene (TNT)	118-96-7	2.11E+02	3.60E+01	1.07E+03	5.73E+02	7.50E+03	1.61E+02	2.53E+01	9.80E+00	8.61E-01
Uranium (soluable salts)	--		2.34E+02		3.88E+03		2.77E+02		5.92E+01	5.33E+02
Vanadium	7440-62-2		3.94E+02		6.53E+03		6.14E+02		6.31E+01	1.26E+03
Vinyl acetate	108-05-4		2.56E+03		1.24E+04		2.30E+03		4.09E+02	1.50E+00
Vinyl bromide	593-60-2	5.78E+00	9.66E+00	2.80E+01	4.55E+01	1.30E+02	8.46E+00	3.74E+00	6.26E+00	1.97E-02
Vinyl chloride (Chlorothene)	75-01-4	7.42E-01	1.13E+02	2.84E+01	8.16E+02	1.61E+02	1.62E+02	3.24E-01	4.43E+01	1.34E-02
m-Xylene	108-38-3		7.64E+02		3.73E+03		6.96E+02		1.93E+02	2.97E+00
o-Xylene	95-47-6		8.05E+02		3.94E+03		7.36E+02		1.93E+02	2.98E+00
p-Xylene	106-42-3		7.92E+02		3.87E+03		7.23E+02		1.93E+02	2.99E+00
Xylenes	1330-20-7		8.71E+02		4.28E+03		7.98E+02		1.93E+02	1.54E+02
Zinc	7440-66-6		2.35E+04		3.89E+05		1.06E+05		5.96E+03	7.41E+03
Essential Nutrients										
Calcium			1.30E+07		3.24E+07		8.85E+06			
Chloride			1.20E+07		5.84E+07		1.59E+07			
Magnesium			1.56E+07		5.68E+06		1.55E+06			
Phosphorus			1.56E+07		6.49E+07		1.77E+07			
Potassium			1.56E+07		7.62E+07		2.08E+07			
Sodium			7.82E+06		3.73E+07		1.02E+07			

Table A-2			
Default Exposure Factors			
Symbol	**Definition (units)**	**Default**	**Reference**
CSF_o	Cancer slope factor oral $(mg/kg\text{-}day)^{-1}$	Chem.-spec.	See Appendix C
IUR	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Chem.-spec.	See Appendix C
RfD_o	Reference dose oral (mg/kg-day)	Chem.-spec.	See Appendix C
RfC	Inhalation Reference Concentration (mg/m^3)	Chem.-spec.	See Appendix C
TR	Target cancer risk	1E-05	NMED-specified value
THQ	Target hazard quotient	1	NMED-specified value
BW	Body weight (kg)		
	-- adult	80	US EPA, 2014
	-- child	15	US EPA, 2014
AT	Averaging time (days)		
	-- carcinogens	25550	US EPA, 2014
	-- noncarcinogens	ED*365	
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chem.-spec.	See Appendix C
SA	Exposed surface area for soil/dust (cm^2/day)		
	– adult resident	6,032	US EPA, 2014
	– adult worker	3,470	US EPA, 2014
	-- child	2,690	US EPA, 2014
SA	Exposed surface area for water exposure (cm^2)		
	– adult resident	20,900	US EPA, 2014
	– child resident	6,378	US EPA, 2014
AF	Adherence factor, soils (mg/cm^2)		
	– adult resident	0.07	US EPA, 2014
	– adult worker	0.12	US EPA, 2014
	-- child resident	0.2	US EPA, 2014

	– construction worker	0.3	US EPA, 2014
ABS	Skin absorption defaults (unitless):		
	– semi-volatile organics	Chem.-spec.	See Appendix C
	– volatile organics	Chem.-spec.	See Appendix C
	– inorganics	Chem.-spec.	See Appendix C
IRW	Drinking water ingestion rate (L/day)		
	-- adult	2.5	US EPA, 2014
	-- child	0.78	US EPA, 2014
IRS	Soil ingestion (mg/day)		
	-- adult resident	100	US EPA, 2017
	-- child resident	200	US EPA, 2017
	-- commercial/industrial worker	100	US EPA, 2002
	construction worker	330	US EPA, 2002
EF	Exposure frequency (days/yr)		
	-- residential	350	US EPA, 2014
	-- commercial/industrial	225	US EPA, 2002
	– construction worker	250	US EPA, 2002
ED	Exposure duration (years)		
	-- residential	20[a]	US EPA, 2014
	-- child	6	US EPA, 1991
	-- commercial/industrial	25	US EPA, 2014
	– construction worker	1	US EPA, 2002
ET	Exposure time (unitless)		
	--residential	1	24 hours/day
	--commercial/industrial	0.33	8 hours/day
	--construction worker	0.33	8 hours/day
t_{event_a}	Dermal exposure time per event, water, adult resident (hours/event)	0.71	US EPA, 2014
t_{event_c}	Dermal exposure time per event, water, child resident (hours/event)	0.54	US EPA, 2014
PEF	Particulate emission factor (m^3/kg)	Chem.-spec.	US EPA, 2002

VFs	Volatilization factor for soil (m^3/kg)	Chem.-spec.	US EPA, 2002
K	Andelman volatilization factor for water (L/m^3)	0.5	US EPA, 1991
C_{sat}	Soil saturation concentration (mg/kg)	Chem.-spec.	US EPA, 2002

[a]Exposure duration for lifetime residents is assumed to be 26 years total. For carcinogens, exposures are combined for children (6 years) and adults (20 years).
Chem.-spec.- Chemical-specific value

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Table A-3. Summary of Soil-to-Groundwater Screening Levels

Chemical	Risk-based SSL, DAF 1 (mg/kg)	Risk-based SSL, DAF 20 (mg/kg)	NMGW/MCL-based SSL, DAF 1 (mg/kg)	NMGW/MCL-based SSL, DAF 20 (mg/kg)	Screening Level Cw (mg/kg)
Acenaphthene	4.12E+00	8.25E+01	1.54E-03	3.09E-02	8.25E+01
Acetaldehyde	3.29E-03	6.58E-02			6.58E-02
Acetone	2.49E+00	4.98E+01			4.98E+01
Acetophenone	4.82E-01	9.64E+00			9.64E+00
Acrolein	7.29E-06	1.46E-04			1.46E-04
Acrylonitrile	9.77E-05	1.95E-03			1.95E-03
Alachlor	8.78E-05	1.76E-03	1.28E-03	2.57E-02	2.57E-02
Aldrin	2.44E-04	4.88E-03			4.88E-03
Aluminum	2.99E+04	5.97E+05			5.97E+05
2-Amino-4,6-dinitrotoluene	1.15E-03	2.30E-02			2.30E-02
4-Amino-2,6-dinitrotoluene	1.15E-03	2.30E-02			2.30E-02
Ammonium Picrate	1.40E-01	2.81E+00			2.81E+00
Anthracene	4.25E+01	8.51E+02			8.51E+02
Antimony	3.28E-01	6.56E+00	2.71E-01	5.42E+00	6.56E+00
Arsenic	2.50E-02	4.99E-01	2.92E-01	5.83E+00	5.83E+00
Atrazine	1.70E-03	3.41E-02	1.51E-03	3.02E-02	3.41E-02
Barium	1.35E+02	2.70E+03	8.23E+01	1.65E+03	2.70E+03
Benzene	1.90E-03	3.80E-02	2.09E-03	4.18E-02	4.18E-02
Benzidine	2.13E-06	4.27E-05			4.27E-05
Benzo(a)anthracene	3.18E-02	6.37E-01			6.37E-01
Benzo(a)pyrene	2.21E-01	4.42E+00	1.76E-01	3.53E+00	4.42E+00
Benzo(b)fluoranthene	3.09E-01	6.17E+00			6.17E+00
Benzo(k)fluoranthene	3.02E+00	6.05E+01			6.05E+01
Beryllium	9.79E+00	1.96E+02	3.16E+00	6.32E+01	1.96E+02
a-BHC (a-Hexachlorocyclohexane, a-HCH)	3.04E-04	6.08E-03			6.08E-03
b-BHC (b-Hexachlorocyclohexane, b-HCH)	1.06E-03	2.13E-02			2.13E-02
t-BHC (t-Hexachlorocyclohexane, Lindane)	1.82E-03	3.64E-02			3.64E-02
1,1-Biphenyl	6.56E-03	1.31E-01			1.31E-01

Chemical	Risk-based SSL, DAF 1 (mg/kg)	Risk-based SSL, DAF 20 (mg/kg)	NMGW/MCL-based SSL, DAF 1 (mg/kg)	NMGW/MCL-based SSL, DAF 20 (mg/kg)	Screening Level Cw (mg/kg)
Bis(2-chloroethyl) ether	3.03E-05	6.05E-04			6.05E-04
Bis(2-chloroisopropyl) ether	2.38E-03	4.75E-02			4.75E-02
Bis(2-ethylhexyl) phthalate [Di(2-ethylhexyl)phthalate, DEHP]	9.99E+00	2.00E+02	1.08E+00	2.15E+01	2.00E+02
Bis(chloromethyl) ether	1.50E-07	3.00E-06			3.00E-06
Boron	1.25E+01	2.51E+02			2.51E+02
Bromodichloromethane	3.10E-04	6.21E-03			6.21E-03
Bromomethane	1.71E-03	3.43E-02			3.43E-02
1,3-Butadiene	4.07E-04	8.13E-03			8.13E-03
2-Butanone (Methyl ethyl ketone, MEK)	1.00E+00	2.01E+01			2.01E+01
tert-Butyl methyl ether (MTBE)	2.77E-02	5.53E-01			5.53E-01
Cadmium	4.69E-01	9.39E+00	3.76E-01	7.52E+00	9.39E+00
Carbofuran	2.96E-02	5.91E-01	1.26E-02	2.53E-01	5.91E-01
Carbon disulfide	2.21E-01	4.42E+00			4.42E+00
Carbon tetrachloride	1.67E-03	3.34E-02	1.84E-03	3.67E-02	3.67E-02
Chlordane	2.28E-02	4.56E-01	1.02E-01	2.03E+00	2.03E+00
2-Chloroacetophenone					
2-Chloro-1,3-butadiene	9.83E-05	1.97E-03			1.97E-03
1-Chloro-1,1-difluoroethane	5.34E+01	1.07E+03			1.07E+03
Chlorobenzene (Monochlorobenzene)	4.18E-02	8.36E-01	5.39E-02	1.08E+00	1.08E+00
1-Chlorobutane	2.27E-01	4.53E+00			4.53E+00
Chlorodifluoromethane	4.27E+01	8.55E+02			8.55E+02
Chloroform	5.46E-04	1.09E-02			1.09E-02
Chloromethane	4.76E-03	9.52E-02			9.52E-02
b-Chloronaphthalene	2.85E+00	5.70E+01			5.70E+01
o-Chloronitrobenzene	1.72E-03	3.44E-02			3.44E-02
p-Chloronitrobenzene	1.28E-02	2.57E-01			2.57E-01
2-Chlorophenol	5.76E-02	1.15E+00			1.15E+00
2-Chloropropane	6.31E-02	1.26E+00			1.26E+00
o-Chlorotoluene	1.78E-01	3.56E+00			3.56E+00
Chromium III	2.46E+07	4.91E+08			4.91E+08

Chemical	Risk-based SSL, DAF 1 (mg/kg)	Risk-based SSL, DAF 20 (mg/kg)	NMGW/MCL-based SSL, DAF 1 (mg/kg)	NMGW/MCL-based SSL, DAF 20 (mg/kg)	Screening Level Cw (mg/kg)
Chromium VI	9.61E-03	1.92E-01			1.92E-01
Chromium (Total)	1.03E+04	2.05E+05	1.80E+05	3.60E+03	2.05E+05
Chrysene	9.30E+00	1.86E+02			1.86E+02
Cobalt	2.70E-01	5.40E+00			5.40E+00
Copper	2.78E+01	5.56E+02	4.57E+01	9.15E+02	9.15E+02
Crotonaldehyde	7.11E-05	1.42E-03			1.42E-03
Cumene (isopropylbenzene)	5.69E-01	1.14E+01			1.14E+01
Cyanide	2.61E-04	5.22E-03	3.56E-02	7.13E-01	7.13E-01
Cyanogen	4.01E-03	8.01E-02			8.01E-02
Cyanogen bromide	5.29E-01	1.06E+01			1.06E+01
Cyanogen chloride	2.94E-01	5.88E+00			5.88E+00
Cyclohexane	7.46E-02	1.49E+00			1.49E+00
DDD	5.60E-02	1.12E+00			1.12E+00
DDE	8.15E-02	1.63E+00			1.63E+00
DDT	5.80E-01	1.16E+01			1.16E+01
Dibenz(a,h)anthracene	9.84E-02	1.97E+00			1.97E+00
1,2-Dibromo-3-chloropropane	1.16E-06	2.33E-05	6.95E-05	1.39E-03	1.39E-03
Dibromochloromethane	3.77E-04	7.55E-03			7.55E-03
1,2-Dibromoethane (Ethylene dibromide)	1.76E-05	3.52E-04	1.18E-05	2.36E-04	3.52E-04
1,4-Dichloro-2-butene	5.00E-06	9.99E-05			9.99E-05
1,2-Dichlorobenzene	2.29E-01	4.58E+00	4.54E-01	9.08E+00	9.08E+00
1,4-Dichlorobenzene	3.60E-03	7.20E-02	5.61E-02	1.12E+00	1.12E+00
3,3-Dichlorobenzidine	6.21E-03	1.24E-01			1.24E-01
Dichlorodifluoromethane	3.61E-01	7.23E+00			7.23E+00
1,1-Dichloroethane	6.80E-03	1.36E-01			1.36E-01
1,2-Dichloroethane	4.07E-04	8.14E-03	1.19E-03	2.38E-02	2.38E-02
cis-1,2-Dichloroethene	9.18E-03	1.84E-01	1.76E-02	3.52E-01	3.52E-01
trans-1,2-Dichloroethene	1.71E-02	3.42E-01	2.52E-02	5.03E-01	5.03E-01
1,1-Dichloroethene	9.74E-02	1.95E+00	2.40E-03	4.79E-02	1.95E+00
2,4-Dichlorophenol	4.13E-02	8.25E-01			8.25E-01
1,2-Dichloropropane	1.21E-03	2.43E-02	1.39E-03	2.77E-02	2.77E-02

Chemical	Risk-based SSL, DAF 1 (mg/kg)	Risk-based SSL, DAF 20 (mg/kg)	NMGW/MCL-based SSL, DAF 1 (mg/kg)	NMGW/MCL-based SSL, DAF 20 (mg/kg)	Screening Level Cw (mg/kg)
1,3-Dichloropropene	1.40E-03	2.81E-02			2.81E-02
Dicyclopentadiene	1.71E-03	3.42E-02			3.42E-02
Dieldrin	5.32E-04	1.06E-02			1.06E-02
Diethyl phthalate	4.89E+00	9.79E+01			9.79E+01
Di-n-butyl phthalate (Dibutyl phthalate)	1.69E+00	3.38E+01			3.38E+01
2,4-Dimethylphenol	3.22E-01	6.45E+00			6.45E+00
Dimethyl phthalate (DMP, Phthalic Acid)	1.78E-01	3.57E+00			3.57E+00
4,6-Dinitro-o-cresol	1.99E-03	3.98E-02			3.98E-02
2,4-Dinitrophenol	3.34E-02	6.69E-01			6.69E-01
2,4-Dinitrotoluene	2.46E-03	4.92E-02			4.92E-02
2,6-Dintitrotoluene	5.12E-04	1.02E-02			1.02E-02
2,4/2,6-Dintrotoluene Mixture	1.12E-03	2.24E-02			2.24E-02
1,4-Dioxane	8.14E-04	1.63E-02			1.63E-02
1,2-Diphenylhydrazine	1.90E-03	3.79E-02			3.79E-02
Endosulfan	1.02E+00	2.04E+01			2.04E+01
Endrin	6.77E-02	1.35E+00	6.06E-02	1.21E+00	1.35E+00
Epichlorohydrin	3.86E-04	7.72E-03			7.72E-03
Ethyl acetate	2.64E-02	5.28E-01			5.28E-01
Ethyl acrylate	2.99E-03	5.98E-02			5.98E-02
Ethyl chloride	5.37E+00	1.07E+02			1.07E+02
Ethyl ether	7.60E-01	1.52E+01			1.52E+01
Ethyl methacrylate	9.15E-02	1.83E+00			1.83E+00
Ethylbenzene	1.32E-02	2.64E-01	6.15E-01	1.23E+01	1.23E+01
Ethylene oxide	3.32E-06	6.65E-05			6.65E-05
Fluoranthene	6.69E+01	1.34E+03			1.34E+03
Fluorene	4.00E+00	8.00E+01			8.00E+01
Fluoride	1.78E+02	3.56E+03	6.01E+02	1.20E+04	1.20E+04
Furan	6.12E-03	1.22E-01			1.22E-01
Glyphosate	6.66E+00	1.33E+02	2.33E+00	4.65E+01	1.33E+02
Heptachlor	1.37E-03	2.75E-02	2.48E-02	4.97E-01	4.97E-01
Hexachlorobenzene	9.25E-04	1.85E-02	9.47E-03	1.89E-01	1.89E-01

Chemical	Risk-based SSL, DAF 1 (mg/kg)	Risk-based SSL, DAF 20 (mg/kg)	NMGW/MCL-based SSL, DAF 1 (mg/kg)	NMGW/MCL-based SSL, DAF 20 (mg/kg)	Screening Level Cw (mg/kg)
Hexachloro-1,3-butadiene	2.07E-03	4.13E-02			4.13E-02
Hexachlorocyclopentadiene	9.88E-04	1.98E-02	1.20E-01	2.40E+00	2.40E+00
Hexachloroethane	1.60E-03	3.20E-02			3.20E-02
n-Hexane	2.78E+00	5.57E+01			5.57E+01
HMX	9.72E-01	1.94E+01			1.94E+01
Hydrazine anhydride	1.90E-06	3.81E-05			3.81E-05
Hydrogen cyanide	2.61E-04	5.22E-03			5.22E-03
Indeno(1,2,3-c,d)pyrene	1.00E+00	2.01E+01			2.01E+01
Iron	3.48E+02	6.96E+03			6.96E+03
Isobutanol (Isobutyl alcohol)	1.05E+00	2.10E+01			2.10E+01
Isophorone	2.12E-01	4.23E+00			4.23E+00
Lead			1.35E+01	2.70E+02	2.70E+02
Lead (tetraethyl-)	4.70E-06	9.41E-05			9.41E-05
Maleic hydrazide	1.79E+00	3.57E+01			3.57E+01
Manganese	1.31E+02	2.63E+03			2.63E+03
Mercury (elemental)	3.27E-02	6.54E-01	1.04E-01	2.09E+00	2.09E+00
Mercury (methyl)	3.79E-04	7.58E-03			7.58E-03
Mercury (salts)	2.56E-01	5.13E+00	1.04E-01	2.09E+00	5.13E+00
Methacrylonitrile	3.71E-04	7.43E-03			7.43E-03
Methomyl	9.37E-02	1.87E+00			1.87E+00
Methyl acetate	3.55E+00	7.11E+01			7.11E+01
Methyl acrylate	7.13E-03	1.43E-01			1.43E-01
Methyl isobutyl ketone	2.40E-01	4.80E+00			4.80E+00
Methyl methacrylate	2.61E-01	5.22E+00			5.22E+00
Methyl styrene (alpha)	9.43E-01	1.89E+01			1.89E+01
Methyl styrene (mixture)	4.70E-02	9.40E-01			9.40E-01
Methylcyclohexane	1.58E+01	3.16E+02			3.16E+02
Methylene bromide (Dibromomethane)	1.68E-03	3.35E-02			3.35E-02
Methylene chloride (Dichloromethane)	2.35E-02	4.71E-01	1.11E-03	2.21E-02	4.71E-01
1-Methylnaphthalene	4.47E-02	8.93E-01			8.93E-01
2-Methylnaphthalene	1.38E-01	2.76E+00			2.76E+00

Chemical	Risk-based SSL, DAF 1 (mg/kg)	Risk-based SSL, DAF 20 (mg/kg)	NMGW/MCL-based SSL, DAF 1 (mg/kg)	NMGW/MCL-based SSL, DAF 20 (mg/kg)	Screening Level Cw (mg/kg)
Molybdenum	1.99E+00	3.98E+01			3.98E+01
Naphthalene	2.91E-03	5.83E-02			5.83E-02
Nickel	2.42E+01	4.85E+02			4.85E+02
Nitrate	2.13E+01	4.25E+02	6.73E+00	1.35E+02	4.25E+02
Nitrite	1.33E+00	2.66E+01	6.73E-01	1.35E+01	2.66E+01
Nitrobenzene	7.20E-04	1.44E-02			1.44E-02
Nitroglycerin	6.80E-04	1.36E-02			1.36E-02
p-Nitrophenol					
2-Nitropropane	2.13E-05	4.26E-04			4.26E-04
N-Nitrosodiethylamine	4.97E-07	9.94E-06			9.94E-06
N-Nitrosodimethylamine	1.02E-06	2.04E-05			2.04E-05
N-Nitrosodi-*n*-butylamine	4.21E-05	8.42E-04			8.42E-04
N-Nitrosodiphenylamine	5.02E-01	1.00E+01			1.00E+01
N-Nitrosopyrrolidine	1.15E-04	2.30E-03			2.30E-03
m-Nitrotoluene	1.25E-03	2.50E-02			2.50E-02
o-Nitrotoluene	2.29E-03	4.58E-02			4.58E-02
p-Nitrotoluene	3.06E-02	6.13E-01			6.13E-01
Pentachlorobenzene	1.76E-02	3.52E-01			3.52E-01
Pentachlorophenol	3.14E-03	6.29E-02	7.61E-03	1.52E-01	1.52E-01
Perchlorate	5.85E-03	1.17E-01	6.35E-04	1.27E-02	1.17E-01
Perfluorinate chemicals (PFCs)					
Perfluorohexane sulfonic acid (PFHxS)					
Perfluorooctane sulfonate (PFO, PFOS)					
Perfluorooctanoic acid (PFOA)					
Perfluorobutane sulfonate (PFBS)					
Perfluorononanoic acid (PFNA)					
Phenanthrene	4.30E+00	8.59E+01			8.59E+01
Phenol	2.62E+00	5.23E+01			5.23E+01
Picric Acid (2,4,6-Trinitrophenol)	1.40E-01	2.81E+00			2.81E+00
Polychlorinatedbiphenyls (PCBs)					
Aroclor 1016	1.01E-01	2.01E+00	3.59E-02	7.17E-01	2.01E+00

Chemical	Risk-based SSL, DAF 1 (mg/kg)	Risk-based SSL, DAF 20 (mg/kg)	NMGW/MCL-based SSL, DAF 1 (mg/kg)	NMGW/MCL-based SSL, DAF 20 (mg/kg)	Screening Level Cw (mg/kg)
Aroclor 1221	7.17E-04	1.43E-02			1.43E-02
Aroclor 1232	7.17E-04	1.43E-02			1.43E-02
Aroclor 1242	9.22E-03	1.84E-01			1.84E-01
Aroclor 1248	9.04E-03	1.81E-01			1.81E-01
Aroclor 1254	1.54E-02	3.08E-01			3.08E-01
Aroclor 1260	4.13E-02	8.25E-01			8.25E-01
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	3.21E-02	6.42E-01			6.42E-01
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	3.14E-01	6.29E+00			6.29E+00
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	2.07E-02	4.15E-01			4.15E-01
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	1.24E-02	2.48E-01			2.48E-01
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	1.27E-02	2.53E-01			2.53E-01
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	1.27E-02	2.53E-01			2.53E-01
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	1.24E-05	2.48E-04			2.48E-04
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	7.74E-03	1.55E-01			1.55E-01
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	7.59E-03	1.52E-01			1.52E-01
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	7.74E-03	1.55E-01			1.55E-01
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	7.74E-03	1.55E-01			1.55E-01
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	2.28E-06	4.55E-05			4.55E-05
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	7.03E-03	1.41E-01			1.41E-01
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	4.64E-04	9.27E-03			9.27E-03
Prometon	9.58E-02	1.92E+00			1.92E+00
Propylene oxide	4.82E-04	9.65E-03			9.65E-03
Pyrene	9.59E+00	1.92E+02			1.92E+02
RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine	2.96E-03	5.93E-02			5.93E-02
Selenium	5.11E-01	1.02E+01	2.59E-01	5.17E+00	1.02E+01
Silver	6.88E-01	1.38E+01			1.38E+01
Simazine	2.42E-03	4.83E-02	1.59E-03	3.19E-02	4.83E-02
Strontium	4.17E+02	8.33E+03			8.33E+03
Styrene	1.03E+00	2.06E+01	8.55E-02	1.71E+00	2.06E+01
Sulfolane	3.75E-03	7.49E-02			7.49E-02
2,3,7,8-TCDD	4.43E-07	8.86E-06	1.12E-05	2.24E-04	2.24E-04

Chemical	Risk-based SSL, DAF 1 (mg/kg)	Risk-based SSL, DAF 20 (mg/kg)	NMGW/MCL-based SSL, DAF 1 (mg/kg)	NMGW/MCL-based SSL, DAF 20 (mg/kg)	Screening Level Cw (mg/kg)
2,3,7,8-TCDF	3.85E-07	7.69E-06			7.69E-06
1,2,4,5-Tetrachlorobenzene	5.83E-03	1.17E-01			1.17E-01
1,1,1,2-Tetrachloroethane	1.80E-03	3.60E-02			3.60E-02
1,1,2,2-Tetrachloroethane	2.40E-04	4.81E-03			4.81E-03
Tetrachloroethene	1.60E-02	3.21E-01	1.99E-03	3.98E-02	3.21E-01
N,N,N',N''-tetramethylphosphoramide (TMPA)	3.47E-04	6.95E-03			6.95E-03
Tetryl (Trinitrophenylmethylnitramine)	2.79E-01	5.59E+00			5.59E+00
Thallium	1.41E-02	2.81E-01	1.42E-01	2.85E+00	2.85E+00
Toluene	6.07E-01	1.21E+01	5.55E-01	1.11E+01	1.21E+01
Toxaphene	1.83E-02	3.66E-01	3.48E-01	6.96E+00	6.96E+00
Tribromomethane (Bromoform)	7.34E-03	1.47E-01			1.47E-01
1,1,2-Trichloro-1,2,2-trifluoroethane	1.60E+02	3.20E+03			3.20E+03
1,2,4-Trichlorobenzene	8.82E-03	1.76E-01	1.55E-01	3.10E+00	3.10E+00
1,1,1-Trichloroethane	2.55E+00	5.11E+01	6.38E-02	1.28E+00	5.11E+01
1,1,2-Trichloroethane	1.11E-04	2.23E-03	1.34E-03	2.68E-02	2.68E-02
Trichloroethylene	8.04E-04	1.61E-02	1.55E-03	3.10E-02	3.10E-02
Trichlorofluoromethane	7.84E-01	1.57E+01			1.57E+01
2,4,5-Trichlorophenol	3.31E+00	6.62E+01			6.62E+01
2,4,6-Trichlorophenol	3.37E-02	6.74E-01			6.74E-01
1,1,2-Trichloropropane	2.79E-02	5.59E-01			5.59E-01
1,2,3-Trichloropropane	2.91E-06	5.82E-05			5.82E-05
Triethylamine	3.65E-03	7.31E-02			7.31E-02
2,4,6-Trinitrotoluene	4.30E-02	8.61E-01			8.61E-01
Uranium (soluable salts)	2.67E+01	5.33E+02		2.70E+02	5.33E+02
Vanadium	6.31E+01	1.26E+03			1.26E+03
Vinyl acetate	7.52E-02	1.50E+00			1.50E+00
Vinyl bromide	9.85E-04	1.97E-02			1.97E-02
Vinyl chloride	1.08E-04	2.17E-03	6.70E-04	1.34E-02	1.34E-02
m-Xylene	1.48E-01	2.97E+00			2.97E+00
o-Xylene	1.49E-01	2.98E+00			2.98E+00
p-Xylene	1.50E-01	2.99E+00			2.99E+00

Chemical	Risk-based SSL, DAF 1 (mg/kg)	Risk-based SSL, DAF 20 (mg/kg)	NMGW/MCL-based SSL, DAF 1 (mg/kg)	NMGW/MCL-based SSL, DAF 20 (mg/kg)	Screening Level Cw (mg/kg)
Xylenes	1.49E-01	2.98E+00	7.72E+00	1.54E+02	1.54E+02
Zinc	3.71E+02	7.41E+03			7.41E+03
Essential Nutrients					
Calcium					
Chloride					
Magnesium					
Phosphorus					
Potassium					
Sodium					

Table A-4. NMED Vapor Intrusion Screening Levels (VISLs)

	Residential Indoor Air (µg/m³)	End Point	Residential VISL_sg (µg/m³)	End Point	Residential VISL_gw (µg/L)	End Point	Industrial Indoor Air (µg/m³)	End Point	Industrial VISL_sg (µg/m³)	End Point	Industrial VISL_gw (µg/L)	End Point	VOC?	Inhalation Toxicity?
Acenaphthene														no
Acetaldehyde	9.39E+00	n	3.13E+02	n	3.43E+03	n	4.42E+01	n	1.47E+03	n	1.62E+04	n	a	yes
Acetone	3.23E+04	n	1.08E+06	n	2.25E+07	n	1.52E+05	n	5.08E+06	n	1.06E+08	n	a	yes
Acetophenone													a	no
Acrolein	2.09E-02	n	6.95E-01	n	4.17E+00	n	9.83E-02	n	3.28E+00	n	1.97E+01	n	a	yes
Acrylonitrile	4.13E-01	c	1.38E+01	c	7.30E+01	c	2.02E+00	c	6.75E+01	c	3.58E+02	c	a	yes
Alachlor														no
Aldrin	5.73E-03	c	1.91E-01	c	3.18E+00	c	2.81E-02	c	9.36E-01	c	1.56E+01	c	a	yes
Aluminum														yes
Anthracene													a	no
Antimony														no
Arsenic														yes
Atrazine														
Barium														yes
Benzene	3.60E+00	c	1.20E+02	c	1.58E+01	c	1.76E+01	c	5.88E+02	c	7.76E+01	c	a	yes
Benzidine														yes
Benzo(a)anthracene	9.22E-02	c	3.07E+00	c	1.87E+02	c	1.25E+00	c	4.17E+01	c	2.54E+03	c	a	yes
Benzo(a)pyrene														yes
Benzo(b)fluoranthene														yes
Benzo(k)fluoranthene														yes
Beryllium														yes
a-BHC (HCH)														yes
b-BHC (HCH)														yes
g-BHC														yes
1,1-Biphenyl	4.17E-01	n	1.39E+01	n	3.30E+01	n	1.97E+00	n	6.55E+01	n	1.56E+02	n	a	yes
Bis(2-chloroethyl) ether	8.51E-02	c	2.84E+00	c	1.22E+02	c	4.17E-01	c	1.39E+01	c	5.98E+02	c	a	yes
Bis(2-chloroisopropyl) ether													a	no

	Residential Indoor Air (µg/m^3)	End Point	Residential VISL_sg (µg/m^3)	End Point	Residential VISL_gw (µg/L)	End Point	Industrial Indoor Air (µg/m^3)	End Point	Industrial VISL_sg (µg/m^3)	End Point	Industrial VISL_gw (µg/L)	End Point	VOC?	Inhalation Toxicity?
Bis(2-ethylhexyl) phthalate														yes
Bis(chloromethyl) ether	4.53E-04	c	1.51E-02	c	2.53E-03	c	2.22E-03	c	7.40E-02	c	1.24E-02	c	a	yes
Boron														yes
Bromodichloromethane	7.59E-01	c	2.53E+01	c	8.73E+00	c	3.72E+00	c	1.24E+02	c	4.28E+01	c	a	yes
Bromomethane	5.21E+00	n	1.74E+02	n	1.73E+01	n	2.46E+01	n	8.19E+02	n	8.17E+01	n	a	yes
1,3-Butadiene	9.36E-01	c	3.12E+01	c	3.10E-01	c	4.59E+00	c	1.53E+02	c	1.52E+00	c	a	yes
2-Butanone (Methyl ethyl ketone, MEK)	5.21E+03	n	1.74E+05	n	2.24E+06	n	2.46E+04	n	8.19E+05	n	1.05E+07	n	a	yes
tert-Butyl methyl ether (MTBE)	1.08E+02	c	3.60E+03	c	4.49E+03	c	5.29E+02	c	1.76E+04	c	2.20E+04	c	a	yes
Cadmium														yes
Carbofuran														no
Carbon disulfide	7.30E+02	n	2.43E+04	n	1.24E+03	n	3.44E+03	n	1.15E+05	n	5.83E+03	n	a	yes
Carbon tetrachloride	4.68E+00	c	1.56E+02	c	4.14E+00	c	2.29E+01	c	7.65E+02	c	2.03E+01	c	a	yes
Chlordane	2.81E-01	c	9.36E+00	c	1.41E+02	c	1.38E+00	c	4.59E+01	c	6.91E+02	c	a	yes
2-Chloroacetophenone														yes
2-Chloro-1,3-butadiene	9.36E-02	c	3.12E+00	c	4.07E-02	c	4.59E-01	c	1.53E+01	c	1.99E-01	c	a	yes
1-Chloro-1,1-difluoroethane	5.21E+04	n	1.74E+06	n	2.16E+04	n	2.46E+05	n	8.19E+06	n	1.02E+05	n	a	yes
Chlorobenzene	5.21E+01	n	1.74E+03	n	4.09E+02	n	2.46E+02	n	8.19E+03	n	1.93E+03	n	a	yes
1-Chlorobutane													a	no
Chlorodifluoromethane	5.21E+04	n	1.74E+06	n	3.13E+04	n	2.46E+05	n	8.19E+06	n	1.48E+05	n	a	yes
Chloroform	1.22E+00	c	4.07E+01	c	8.11E+00	c	5.98E+00	c	1.99E+02	c	3.98E+01	c	a	yes
Chloromethane	1.56E+01	c	5.20E+02	c	4.31E+01	c	7.65E+01	c	2.55E+03	c	2.11E+02	c	a	yes
b-Chloronaphthalene													a	no
o-Chloronitrobenzene														yes
p-Chloronitrobenzene														yes
2-Chlorophenol													a	no
2-Chloropropane	1.04E+02	n	3.48E+03	n	1.45E+02	n	4.92E+02	n	1.64E+04	n	6.85E+02	n	a	yes
o-Chlorotoluene													a	no
Chromium III														no
Chromium VI														yes
Chromium (Total)														yes
Chrysene														yes

	Residential Indoor Air (µg/m^3)	End Point	Residential VISL_sg (µg/m^3)	End Point	Residential VISL_gw (µg/L)	End Point	Industrial Indoor Air (µg/m^3)	End Point	Industrial VISL_sg (µg/m^3)	End Point	Industrial VISL_gw (µg/L)	End Point	VOC?	Inhalation Toxicity?
Cobalt														yes
Copper														no
Crotonaldehyde													a	no
Cumene (isopropylbenzene)	4.17E+02	n	1.39E+04	n	8.85E+02	n	1.97E+03	n	6.55E+04	n	4.17E+03	n	a	yes
Cyanide	8.34E-01	n	2.78E+01	n	1.53E+02	n	3.93E+00	n	1.31E+02	n	7.21E+02	n	a	yes
Cyanogen													a	no
Cyanogen bromide													a	no
Cyanogen chloride													a	no
Cyclohexane	1.04E+03	n	3.48E+04	n	1.70E+02	n	4.92E+03	n	1.64E+05	n	8.02E+02	n	a	yes
DDD														yes
DDE	2.89E-01	c	9.65E+00	c	1.70E+02	c	1.42E+00	c	4.73E+01	c	8.32E+02	c	a	yes
DDT														yes
Dibenz(a,h)anthracene														yes
1,2-Dibromo-3-chloropropane	1.69E-03	c	5.63E-02	c	2.80E-01	c	2.29E-02	c	7.65E-01	c	3.81E+00	c	a	yes
Dibromochloromethane	1.04E+00	c	3.47E+01	c	3.24E+01	c	5.10E+00	c	1.70E+02	c	1.59E+02	c	a	yes
1,2-Dibromoethane	4.68E-02	c	1.56E+00	c	1.76E+00	c	2.29E-01	c	7.65E+00	c	8.61E+00	c	a	yes
1,4-Dichloro-2-butene	6.68E-03	c	2.23E-01	c	2.46E-01	c	3.28E-02	c	1.09E+00	c	1.20E+00	c	a	yes
1,2-Dichlorobenzene	2.09E+02	n	6.95E+03	n	2.65E+03	n	9.83E+02	n	3.28E+04	n	1.25E+04	n	a	yes
1,4-Dichlorobenzene	2.55E+00	c	8.51E+01	c	2.58E+01	c	1.25E+01	c	4.17E+02	c	1.27E+02	c	a	yes
3,3-Dichlorobenzidine														yes
Dichlorodifluoromethane	1.04E+02	n	3.48E+03	n	7.42E+00	n	4.92E+02	n	1.64E+04	n	3.50E+01	n	a	yes
1,1-Dichloroethane	1.75E+01	c	5.85E+02	c	7.62E+01	c	8.60E+01	c	2.87E+03	c	3.73E+02	c	a	yes
1,2-Dichloroethane	1.08E+00	c	3.60E+01	c	2.23E+01	c	5.29E+00	c	1.76E+02	c	1.09E+02	c	a	yes
cis-1,2-Dichloroethene													a	no
trans-1,2-Dichloroethene	4.17E+01	n	1.39E+03	n	2.49E+02	n	1.97E+02	n	6.55E+03	n	1.18E+03	n	a	yes
1,1-Dichloroethene	2.09E+02	n	6.95E+03	n	1.95E+02	n	9.83E+02	n	3.28E+04	n	9.19E+02	n	a	yes
2,4-Dichlorophenol														no
1,2-Dichloropropane	2.81E+00	c	9.36E+01	c	2.43E+01	c	1.38E+01	c	4.59E+02	c	1.19E+02	c	a	yes
1,3-Dichloropropene	7.02E+00	c	2.34E+02	c	4.82E+01	c	3.44E+01	c	1.15E+03	c	2.36E+02	c	a	yes
Dicyclopentadiene	3.13E-01	n	1.04E+01	n	1.22E-01	n	1.47E+00	n	4.92E+01	n	5.76E-01	n	a	yes
Dieldrin														yes

	Residential Indoor Air (µg/m^3)	End Point	Residential VISL_sg (µg/m^3)	End Point	Residential VISL_gw (µg/L)	End Point	Industrial Indoor Air (µg/m^3)	End Point	Industrial VISL_sg (µg/m^3)	End Point	Industrial VISL_gw (µg/L)	End Point	VOC?	Inhalation Toxicity?
Diethyl phthalate														no
Di-n-butyl phthalate (Dibutyl phthalate)														no
2,4-Dimethylphenol														no
Dimethyl phthalate														no
4,6-Dinitro-o-cresol														no
2,4-Dinitrophenol														no
2,4-Dinitrotoluene														no
2,6-Dintitrotoluene														no
2,4/2,6-Dintrotoluene Mixture														no
1,4-Dioxane													1	yes
1,2-Diphenylhydrazine														yes
Endosulfan													a	no
Endrin														no
Epichlorohydrin	1.04E+00	n	3.48E+01	n	8.37E+02	n	4.92E+00	n	1.64E+02	n	3.94E+03	n	a	yes
Ethyl acetate	7.30E+01	n	2.43E+03	n	1.33E+04	n	3.44E+02	n	1.15E+04	n	6.26E+04	n	a	yes
Ethyl acrylate													a	no
Ethyl chloride	1.04E+04	n	3.48E+05	n	2.29E+04	n	4.92E+04	n	1.64E+06	n	1.08E+05	n	a	yes
Ethyl ether													a	no
Ethyl methacrylate	3.13E+02	n	1.04E+04	n	1.33E+04	n	1.47E+03	n	4.92E+04	n	6.28E+04	n	a	yes
Ethylbenzene	1.12E+01	c	3.74E+02	c	3.48E+01	c	5.51E+01	c	1.84E+03	c	1.70E+02	c	a	yes
Ethylene oxide	9.36E-03	c	3.12E-01	c	1.54E+00	c	4.59E-02	c	1.53E+00	c	7.56E+00	c	a	yes
Fluoranthene														no
Fluorene													a	no
Fluoride														yes
Furan													a	no
Glyphosate														no
Heptachlor	2.16E-02	c	7.20E-01	c	1.79E+00	c	1.06E-01	c	3.53E+00	c	8.78E+00	c	a	yes
Hexachlorobenzene	6.10E-02	c	2.03E+00	c	8.76E-01	c	2.99E-01	c	9.97E+00	c	4.29E+00	c	a	yes
Hexachloro-1,3-butadiene	1.28E+00	c	4.25E+01	c	3.02E+00	c	6.26E+00	c	2.09E+02	c	1.48E+01	c	a	yes
Hexachlorocyclopentadiene	2.09E-01	n	6.95E+00	n	1.88E-01	n							a	yes
Hexachloroethane	2.55E+00	c	8.51E+01	c	1.60E+01	c	1.25E+01	c	4.17E+02	c	7.85E+01	c	a	yes

	Residential Indoor Air ($\mu g/m^3$)	End Point	Residential VISL_sg ($\mu g/m^3$)	End Point	Residential VISL_gw ($\mu g/L$)	End Point	Industrial Indoor Air ($\mu g/m^3$)	End Point	Industrial VISL_sg ($\mu g/m^3$)	End Point	Industrial VISL_gw ($\mu g/L$)	End Point	VOC?	Inhalation Toxicity?
n-Hexane	7.30E+02	n	2.43E+04	n	9.89E+00	n	3.44E+03	n	1.15E+05	n	4.66E+01	n	a	yes
HMX														no
Hydrazine anhydride	5.73E-03	c	1.91E-01	c	2.29E+02	c	2.81E-02	c	9.36E-01	c	1.12E+03	c	a	yes
Hydrogen cyanide	8.34E-01	n	2.78E+01	n	1.53E+02	n	3.93E+00	n	1.31E+02	n	7.21E+02	n	a	yes
Indeno(1,2,3-c,d)pyrene														yes
Iron														no
Isobutanol (Isobutyl alcohol)														no
Isophorone														yes
Lead														no
Lead (tetraethyl-)													a	no
Maleic hydrazide														no
Manganese														yes
Mercury (elemental)	3.13E-01	n	1.04E+01	n	6.69E-01	n	1.47E+00	n	4.92E+01	n	3.16E+00	n	a	yes
Mercury (methyl)														no
Mercuric Chloride (Mercury Salts)														yes
Methacrylonitrile	3.13E+01	n	1.04E+03	n	3.09E+03	n	1.47E+02	n	4.92E+03	n	1.46E+04	n	a	yes
Methomyl														no
Methyl acetate													a	no
Methyl acrylate	2.09E+01	n	6.95E+02	n	2.56E+03	n	9.83E+01	n	3.28E+03	n	1.21E+04	n	a	yes
Methyl isobutyl ketone	3.13E+03	n	1.04E+05	n	5.53E+05	n	1.47E+04	n	4.92E+05	n	2.61E+06	n	a	yes
Methyl methacrylate	7.30E+02	n	2.43E+04	n	5.58E+04	n	3.44E+03	n	1.15E+05	n	2.63E+05	n	a	yes
Methyl styrene (alpha)													a	no
Methyl styrene (mixture)	4.17E+01	n	1.39E+03	n	3.34E+02	n	1.97E+02	n	6.55E+03	n	1.57E+03	n	a	yes
Methylcyclohexane	3.13E+03	n	1.04E+05	n	1.77E+02	n	1.47E+04	n	4.92E+05	n	8.36E+02	n	a	yes
Methylene bromide (Dibromomethane)	4.17E+00	n	1.39E+02	n	1.24E+02	n	1.97E+01	n	6.55E+02	n	5.83E+02	n	a	yes
Methylene chloride	6.26E+02	n	2.09E+04	n	4.70E+03	n	2.95E+03	n	9.83E+04	n	2.21E+04	n	a	yes
1-Methylnaphthalene													a	no
2-Methylnaphthalene													a	no
Molybdenum														no
Naphthalene	8.26E-01	c	2.75E+01	c	4.58E+01	c	4.05E+00	c	1.35E+02	c	2.24E+02	c	a	yes
Nickel (soluble salts)														yes

	Residential Indoor Air (µg/m^3)	End Point	Residential VISL_sg (µg/m^3)	End Point	Residential VISL_gw (µg/L)	End Point	Industrial Indoor Air (µg/m^3)	End Point	Industrial VISL_sg (µg/m^3)	End Point	Industrial VISL_gw (µg/L)	End Point	VOC?	Inhalation Toxicity?
Nitrate														no
Nitrite														no
Nitrobenzene	7.02E-01	c	2.34E+01	c	7.13E+02	c	3.44E+00	c	1.15E+02	c	3.50E+03	c	a	yes
Nitroglycerin														no
Nitrophenol														no
2-Nitropropane	4.84E-02	c	1.61E+00	c	9.95E+00	c	2.37E-01	c	7.91E+00	c	4.88E+01	c	a	yes
N-Nitrosodiethylamine														yes
N-Nitrosodimethylamine														yes
N-Nitrosodi-*n*-butylamine	1.75E-02	c	5.85E-01	c	3.24E+01	c	8.60E-02	c	2.87E+00	c	1.59E+02	c	a	yes
N-Nitrosodiphenylamine														yes
N-Nitrosopyrrolidine														yes
m-Nitrotoluene														no
o-Nitrotoluene													a	no
p-Nitrotoluene														no
Pentachlorobenzene													a	no
Pentachlorophenol														yes
Perchlorate														no
Perfluorinate chemicals (PFCs)														no
Perfluorohexane sulfonic acid (PFHxS)														no
Perfluorooctane sulfonate (PFO, PFOS)														no
Perfluorooctanoic acid (PFOA)														no
Phenanthrene													a	no
Phenol														yes
Polychlorinatedbiphenyls														no
Aroclor 1016	1.40E+00	c	4.68E+01	c	1.71E+02	c	6.88E+00	c	2.29E+02	c	8.39E+02	c	a	yes
Aroclor 1221	4.93E-02	c	1.64E+00	c	1.63E+00	c	2.41E-01	c	8.05E+00	c	8.00E+00	c	a	yes
Aroclor 1232	4.93E-02	c	1.64E+00	c	1.63E+00	c	2.41E-01	c	8.05E+00	c	8.00E+00	c	a	yes
Aroclor 1242	4.93E-02	c	1.64E+00	c	6.32E+00	c	2.41E-01	c	8.05E+00	c	3.10E+01	c	a	yes
Aroclor 1248	4.93E-02	c	1.64E+00	c	2.73E+00	c	2.41E-01	c	8.05E+00	c	1.34E+01	c	a	yes
Aroclor 1254	4.93E-02	c	1.64E+00	c	4.25E+00	c	2.41E-01	c	8.05E+00	c	2.08E+01	c	a	yes
Aroclor 1260	4.93E-02	c	1.64E+00	c	3.58E+00	c	2.41E-01	c	8.05E+00	c	1.75E+01	c	a	yes

	Residential Indoor Air (µg/m^3)	End Point	Residential VISL_sg (µg/m^3)	End Point	Residential VISL_gw (µg/L)	End Point	Industrial Indoor Air (µg/m^3)	End Point	Industrial VISL_sg (µg/m^3)	End Point	Industrial VISL_gw (µg/L)	End Point	VOC?	Inhalation Toxicity?
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)														yes
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)														yes
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	2.46E-02	c	8.21E-01	c	1.18E+01	c	1.21E-01	c	4.02E+00	c	5.81E+01	c	a	yes
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	2.46E-02	c	8.21E-01	c	8.77E+00	c	1.21E-01	c	4.02E+00	c	4.30E+01	c	a	yes
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	2.46E-02	c	8.21E-01	c	8.77E+00	c	1.21E-01	c	4.02E+00	c	4.30E+01	c	a	yes
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	2.46E-02	c	8.21E-01	c	4.20E+00	c	1.21E-01	c	4.02E+00	c	2.06E+01	c	a	yes
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	2.46E-05	c	8.21E-04	c	8.77E-03	c	1.21E-04	c	4.02E-03	c	4.30E-02	c	a	yes
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	2.46E-02	c	8.21E-01	c	6.50E+00	c	1.21E-01	c	4.02E+00	c	3.19E+01	c	a	yes
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	2.46E-02	c	8.21E-01	c	2.09E+00	c	1.21E-01	c	4.02E+00	c	1.02E+01	c	a	yes
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	2.46E-02	c	8.21E-01	c	2.12E+00	c	1.21E-01	c	4.02E+00	c	1.04E+01	c	a	yes
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	2.46E-02	c	8.21E-01	c	6.50E+00	c	1.21E-01	c	4.02E+00	c	3.19E+01	c	a	yes
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	7.39E-06	c	2.46E-04	c	1.95E-03	c	3.62E-05	c	1.21E-03	c	9.56E-03	c	a	yes
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)														yes
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	2.46E-03	c	8.21E-02	c	4.81E-01	c	1.21E-02	c	4.02E-01	c	2.36E+00	c	a	yes
Prometon														no
Propylene oxide	7.59E+00	c	2.53E+02	c	2.66E+03	c	3.72E+01	c	1.24E+03	c	1.30E+04	c	a	yes
Pyrene													a	no
RDX														no
Selenium														yes
Silver														no
Simazine														no
Strontium														no
Styrene	1.04E+03	n	3.48E+04	n	9.25E+03	n	4.92E+03	n	1.64E+05	n	4.36E+04	n	a	yes
Sulfolane														yes
2,3,7,8-TCDD	7.39E-07	c	2.46E-05	c	3.60E-04	c	3.62E-06	c	1.21E-04	c	1.77E-03	c	a	yes
2,3,7,8-TCDF	7.39E-06	c	2.46E-04	c	1.08E-02	c	3.62E-05	c	1.21E-03	c	5.29E-02	c	a	yes
1,2,4,5-Tetrachlorobenzene													a	no
1,1,1,2-Tetrachloroethane	3.79E+00	c	1.26E+02	c	3.70E+01	c	1.86E+01	c	6.20E+02	c	1.81E+02	c	a	yes
1,1,2,2-Tetrachloroethane	4.84E-01	c	1.61E+01	c	3.22E+01	c	2.37E+00	c	7.91E+01	c	1.58E+02	c	a	yes
Tetrachloroethene	4.17E+01	n	1.39E+03	n	5.75E+01	n	1.97E+02	n	6.55E+03	n	2.71E+02	n	a	yes
Tetryl (Trinitrophenylmethylnitramine)														no

	Residential Indoor Air (µg/m^3)	End Point	Residential VISL_sg (µg/m^3)	End Point	Residential VISL_gw (µg/L)	End Point	Industrial Indoor Air (µg/m^3)	End Point	Industrial VISL_sg (µg/m^3)	End Point	Industrial VISL_gw (µg/L)	End Point	VOC?	Inhalation Toxicity?
Thallium														no
Toluene	5.21E+03	n	1.74E+05	n	1.92E+04	n	2.46E+04	n	8.19E+05	n	9.03E+04	n	a	yes
Toxaphene														yes
Tribromomethane (Bromoform)	2.55E+01	c	8.51E+02	c	1.16E+03	c	1.25E+02	c	4.17E+03	c	5.70E+03	c	a	yes
1,1,2-Trichloro-1,2,2-trifluoroethane	3.13E+04	n	1.04E+06	n	1.45E+03	n	1.47E+05	n	4.92E+06	n	6.84E+03	n	a	yes
1,2,4-Trichlorobenzene	2.09E+00	n	6.95E+01	n	3.58E+01	n	9.83E+00	n	3.28E+02	n	1.69E+02	n	a	yes
1,1,1-Trichloroethane	5.21E+03	n	1.74E+05	n	7.39E+03	n	2.46E+04	n	8.19E+05	n	3.49E+04	n	a	yes
1,1,2-Trichloroethane	2.09E-01	n	6.95E+00	n	6.17E+00	n	9.83E-01	n	3.28E+01	n	2.91E+01	n	a	yes
Trichloroethylene	2.09E+00	n	6.95E+01	n	5.16E+00	n	9.83E+00	n	3.28E+02	n	2.43E+01	n	a	yes
Trichlorofluoromethane	7.30E+02	n	2.43E+04	n	1.84E+02	n	3.44E+03	n	1.15E+05	n	8.65E+02	n	a	yes
2,4,5-Trichlorophenol														no
2,4,6-Trichlorophenol														yes
1,1,2-Trichloropropane													a	no
1,2,3-Trichloropropane	3.13E-01	n	1.04E+01	n	2.22E+01	n	1.47E+00	n	4.92E+01	n	1.05E+02	n	a	yes
Triethylamine	7.30E+00	n	2.43E+02	n	1.19E+03	n	3.44E+01	n	1.15E+03	n	5.63E+03	n	a	yes
2,4,6-Trinitrotoluene														no
Uranium (soluable salts)														yes
Vanadium														yes
Vinyl acetate	2.09E+02	n	6.95E+03	n	9.96E+03	n	9.83E+02	n	3.28E+04	n	4.69E+04	n	a	yes
Vinyl bromide	1.87E+00	c	6.24E+01	c	3.71E+00	c	9.18E+00	c	3.06E+02	c	1.82E+01	c	a	yes
Vinyl chloride	1.68E+00	c	5.59E+01	c	1.47E+00	c	3.13E+01	c	1.04E+03	c	2.74E+01	c	a	yes
m-Xylene	1.04E+02	n	3.48E+03	n	3.54E+02	n	4.92E+02	n	1.64E+04	n	1.67E+03	n	a	yes
o-Xylene	1.04E+02	n	3.48E+03	n	4.91E+02	n	4.92E+02	n	1.64E+04	n	2.31E+03	n	a	yes
p-Xylene	1.04E+02	n	3.48E+03	n	3.69E+02	n	4.92E+02	n	1.64E+04	n	1.74E+03	n	a	yes
Xylenes	1.04E+02	n	3.48E+03	n	4.91E+02	n	4.92E+02	n	1.64E+04	n	2.31E+03	n	a	yes
Zinc														no
PETROLEUM HYDROCARBONS														
Aliphatics C5 to C8	6.26E+02	n	2.09E+04	n	1.16E+01	n	2.95E+03	n	9.83E+04	n	5.46E+01	n	a	yes
C9 to C12	1.04E+02	n	3.48E+03	n	1.60E+00	n	4.92E+02	n	1.64E+04	n	7.56E+00	n	a	yes
C9 to C18	1.04E+02	n	3.48E+03	n	1.51E+00	n	4.92E+02	n	1.64E+04	n	7.12E+00	n	a	yes

	Residential Indoor Air (µg/m^3)	End Point	Residential VISL_sg (µg/m^3)	End Point	Residential VISL_gw (µg/L)	End Point	Industrial Indoor Air (µg/m^3)	End Point	Industrial VISL_sg (µg/m^3)	End Point	Industrial VISL_gw (µg/L)	End Point	VOC?	Inhalation Toxicity?
C19 to C36														
Aromatics C9 to C10	3.13E+00	n	1.04E+02	n	9.48E+00	n	1.47E+01	n	4.92E+02	n	4.47E+01	n	a	yes
C11 to C22													a	

APPENDIX B

CHEMICAL AND PHYSICAL PROPERTIES

Table B-1: Chemical CAS and Molecular Weight

Chemical	CAS. NO.	MW (g/mole)	Ref.
Acenaphthene	83-32-9	154.21	EPI
Acetaldehyde	75-07-0	44.05	EPI
Acetone	67-64-1	58.08	EPI
Acetophenone	98-86-2	120.15	EPI
Acrolein	107-02-8	56.06	EPI
Acrylonitrile	107-13-1	53.06	EPI
Alachlor	15972-60-8	270	EPI
Aldrin	309-00-2	364.92	EPI
Aluminum	7429-90-5	26.98	P
Anthracene	120-12-7	178.24	EPI
Antimony	7440-36-0	121.76	P
Arsenic	7440-38-2	74.92	P
Atrazine	1912-24-9	2.20E+02	P
Barium	7440-39-3	137.33	P
Benzene	71-43-2	78.11	EPI
Benzidine	92-87-5	184.24	EPI
Benzo(a)anthracene	56-55-3	228.3	EPI
Benzo(a)pyrene	50-32-8	252.32	EPI
Benzo(b)fluoranthene	205-99-2	252.32	EPI
Benzo(k)fluoranthene	207-08-9	252.32	EPI
Beryllium	7440-41-7	9.01	P
a-BHC (HCH)	319-84-6	290.83	EPI
b-BHC (HCH)	319-85-7	290.83	EPI
g-BHC	58-89-9	290.83	EPI
1,1-Biphenyl	92-52-4	154.21	EPI
Bis(2-chloroethyl) ether	111-44-4	143.01	EPI
Bis(2-chloroisopropyl) ether	108-60-1	171.07	EPI
Bis(2-ethylhexyl) phthalate	117-81-7	390.57	EPI

Chemical	**CAS. NO.**	**MW (g/mole)**	**Ref.**
Bis(chloromethyl) ether	542-88-1	114.96	EPI
Boron	7440-42-8	10.81	P
Bromodichloromethane	75-27-4	163.83	EPI
Bromomethane	74-83-9	94.94	EPI
1,3-Butadiene	106-99-0	54.09	EPI
2-Butanone (Methyl ethyl ketone, MEK)	78-93-3	72.11	EPI
tert-Butyl methyl ether (MTBE)	1634-04-4	88.15	EPI
Cadmium	7440-43-9	112.41	P
Carbofuran	1563-66-2	220	EPI
Carbon disulfide	75-15-0	76.13	EPI
Carbon tetrachloride	56-23-5	153.82	EPI
Chlordane	12789-03-6	409.78	EPI
2-Chloroacetophenone	532-27-4	154.6	EPI
2-Chloro-1,3-butadiene	126-99-8	88.54	EPI
1-Chloro-1,1-difluoroethane	75-68-3	100.5	EPI
Chlorobenzene	108-90-7	112.56	EPI
1-Chlorobutane	109-69-3	92.57	EPI
Chlorodifluoromethane	75-45-6	86.47	EPI
Chloroform	67-66-3	119.38	EPI
Chloromethane	74-87-3	50.49	EPI
b-Chloronaphthalene	91-58-7	162.62	EPI
o-Chloronitrobenzene	88-73-3	157.56	EPI
p-Chloronitrobenzene	100-00-5	157.56	EPI
2-Chlorophenol	95-57-8	128.56	EPI
2-Chloropropane	75-29-6	78.54	EPI
o-Chlorotoluene	95-49-8	126.59	EPI
Chromium III	16065-83-1	52	P
Chromium VI	18540-29-9	52	P
Chromium (Total)		52	P
Chrysene	218-01-9	228.3	EPI

Chemical	CAS. NO.	MW (g/mole)	Ref.
Cobalt	7440-48-4	58.93	EPI
Copper	7440-50-8	63.55	P
Crotonaldehyde	123-73-9	70.09	EPI
Cumene (isopropylbenzene)	98-82-8	120.2	EPI
Cyanide	57-12-5	27.03	EPI
Cyanogen	460-19-5	52.04	EPI
Cyanogen bromide	506-68-3	105.92	EPI
Cyanogen chloride	506-77-4	61.47	EPI
DDD	72-54-8	320.05	EPI
DDE	72-55-9	318.03	EPI
DDT	50-29-3	354.49	EPI
Dibenz(a,h)anthracene	53-70-3	278.36	EPI
1,2-Dibromo-3-chloropropane	96-12-8	236.33	EPI
Dibromochloromethane	124-48-1	208.28	EPI
1,2-Dibromoethane	106-93-4	187.86	EPI
1,4-Dichloro-2-butene	764-41-0	125	EPI
1,2-Dichlorobenzene	95-50-1	147	EPI
1,4-Dichlorobenzene	106-46-7	147	EPI
3,3-Dichlorobenzidine	91-94-1	253.13	EPI
Dichlorodifluoromethane	75-71-8	120.91	EPI
1,1-Dichloroethane	75-34-3	98.96	EPI
1,2-Dichloroethane	107-06-2	98.96	EPI
cis-1,2-Dichloroethene	156-59-2	96.94	EPI
trans-1,2-Dichloroethene	156-60-5	96.94	EPI
1,1-Dichloroethene	75-35-4	96.94	EPI
2,4-Dichlorophenol	120-83-2	163	EPI
1,2-Dichloropropane	78-87-5	112.99	EPI
1,3-Dichloropropene	542-75-6	110.97	EPI
Dicyclopentadiene	77-73-6	132.21	EPI
Dieldrin	60-57-1	380.91	EPI

Chemical	CAS. NO.	MW (g/mole)	Ref.
Diethyl phthalate	84-66-2	222.24	EPI
Di-n-butyl phthalate (Dibutyl phthalate)	84-74-2	278.35	EPI
2,4-Dimethylphenol	105-67-9	122.17	EPI
Dimethyl phthalate	100-21-0	170	EPI
4,6-Dinitro-o-cresol	534-52-1	198.14	EPI
2,4-Dinitrophenol	51-28-5	184.11	EPI
2,4-Dinitrotoluene	121-14-2	182.14	EPI
2,6-Dintitrotoluene	606-20-2	182.14	EPI
2,4/2,6-Dintrotoluene Mixture	25321-14-6	182.14	EPI
1,4-Dioxane	123-91-1	88.11	EPI
1,2-Diphenylhydrazine	122-66-7	184.24	EPI
Endosulfan	115-29-7	406.92	EPI
Endrin	72-20-8	380.91	EPI
Epichlorohydrin	106-89-8	92.53	EPI
Ethyl acetate	141-78-6	88.11	EPI
Ethyl acrylate	140-88-5	100.12	EPI
Ethyl chloride	75-00-3	64.52	EPI
Ethyl ether	60-29-7	74.12	EPI
Ethyl methacrylate	97-63-2	114.15	EPI
Ethylbenzene	100-41-4	106.17	EPI
Ethylene oxide	75-21-8	44.05	EPI
Fluoranthene	206-44-0	202.26	EPI
Fluorene	86-73-7	166.22	EPI
Fluoride	7782-41-4	19	P
Furan	110-00-9	68.08	EPI
Gylphosate	1071-83-6	170	EPI
Heptachlor	76-44-8	373.32	EPI
Hexachlorobenzene	118-74-1	284.78	EPI
Hexachloro-1,3-butadiene	87-68-3	260.76	EPI
Hexachlorocyclopentadiene	77-47-4	272.77	EPI

Chemical	CAS. NO.	MW (g/mole)	Ref.
Hexachloroethane	67-72-1	236.74	EPI
n-Hexane	110-54-3	86.18	EPI
HMX	2691-41-0	296.16	EPI
Hydrazine anhydride	302-01-2	32.05	EPI
Hydrogen cyanide	74-90-8	27.03	EPI
Indeno(1,2,3-c,d)pyrene	193-39-5	276.34	EPI
Iron	7439-89-6	55.85	P
Isobutanol (Isobutyl alcohol)	78-83-1	74.12	EPI
Isophorone	78-59-1	138.21	EPI
Lead	7439-92-1	207.2	P
Lead (tetraethyl-)	78-00-2	323.45	EPI
Maleic hydrazide	123-33-1	112.09	EPI
Manganese	7439-96-5	54.94	P
Mercury (elemental)	7439-97-6	200.59	EPI
Mercury (methyl)	22967-92-6	215.63	EPI
Mercury Chloride (Mercury Salts)	7487-94-7	271.5	EPI
Methacrylonitrile	126-98-7	67.09	EPI
Methomyl	16752-77-5	162.21	EPI
Methyl acetate	79-20-9	74.08	EPI
Methyl acrylate	96-33-3	86.09	EPI
Methyl isobutyl ketone	108-10-1	100.16	EPI
Methyl methacrylate	80-62-6	100.12	EPI
Methyl styrene (alpha)	98-83-9	118.18	EPI
Methyl styrene (mixture)	25013-15-4	118.18	EPI
Methylcyclohexane	108-87-2	98.19	EPI
Methylene bromide (Dibromomethane)	74-95-3	173.84	EPI
Methylene chloride	75-09-2	84.93	EPI
1-Methylnaphthalene	90-12-0	140	EPI
2-Methylnaphthalene	91-57-6	140	EPI
Molybdenum	7439-98-7	95.96	P

Chemical	**CAS. NO.**	**MW (g/mole)**	**Ref.**
Naphthalene	91-20-3	128.18	EPI
Nickel	7440-02-0	58.69	EPI
Nitrate	14797-55-8	62	EPI
Nitrite	14797-65-0	47.01	EPI
Nitrobenzene	98-95-3	123.11	EPI
Nitroglycerin	55-63-0	227.09	EPI
Nitrophenol			
N-Nitrosodiethylamine	55-18-5	102.14	EPI
N-Nitrosodimethylamine	62-75-9	74.08	EPI
N-Nitrosodi-*n*-butylamine	924-16-3	158.25	EPI
N-Nitrosodiphenylamine	86-30-6	198.23	EPI
N-Nitrosopyrrolidine	930-55-2	100.12	EPI
m-Nitrotoluene	99-08-1	137.14	EPI
o-Nitrotoluene	88-72-2	137.14	EPI
p-Nitrotoluene	99-99-0	137.14	EPI
Pentachlorobenzene	608-93-5	250.34	EPI
Pentachlorophenol	87-86-5	266.34	EPI
Perchlorate	14797-73-0	99.45	NIST
Perfluorinate chemicals (PFCs)			
Perfluorohexane sulfonic acid (PFHxS)			
Perfluorooctane sulfonate (PFO, PFOS)			
Perfluorooctanoic acid (PFOA)			
Phenanthrene	85-01-8	178.24	EPI
Phenol	108-95-2	94.11	EPI
Polychlorinatedbiphenyls			
Aroclor 1016	12674-11-2	257.55	EPI
Aroclor 1221	11104-28-2	188.66	EPI
Aroclor 1232	11141-16-5	188.66	EPI
Aroclor 1242	53469-21-9	291.99	EPI
Aroclor 1248	12672-29-6	291.99	EPI

Chemical	CAS. NO.	MW (g/mole)	Ref.
Aroclor 1254	11097-69-1	326.44	EPI
Aroclor 1260	11096-82-5	395.33	EPI
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	35065-30-6	395.33	EPI
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	35065-29-3	395.33	EPI
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	39635-31-9	395.33	EPI
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	52663-72-6	360.88	EPI
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	69782-90-7	360.88	EPI
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	38380-08-4	360.88	EPI
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	32774-16-6	360.88	EPI
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	65510-44-3	326.44	EPI
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	31508-00-6	326.44	EPI
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	32598-14-4	326.44	EPI
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	74472-37-0	326.44	EPI
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	57465-28-8	326.44	EPI
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	32598-13-3	291.99	EPI
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	70362-50-4	291.99	EPI
Propylene oxide	75-56-9	58.08	EPI
Pyrene	129-00-0	202.26	EPI
RDX	121-82-4	222.12	EPI
Selenium	7782-49-2	78.96	P
Silver	7440-22-4	107.87	P
Simazine	122-34-9	200	EPI
Strontium	7440-24-6	87.62	P
Styrene	100-42-5	104.15	EPI
Sulfolane	126-33-0	120.17	EPI
2,3,7,8-TCDD	1746-01-6	321.98	EPI
2,3,7,8-TCDF	51207-31-9	305.98	EPI
1,2,4,5-Tetrachlorobenzene	95-94-3	215.89	EPI
1,1,1,2-Tetrachloroethane	630-20-6	167.85	EPI
1,1,2,2-Tetrachloroethane	79-34-5	167.85	EPI

Chemical	CAS. NO.	MW (g/mole)	Ref.
Tetrachloroethene	127-18-4	165.83	EPI
Tetryl (Trinitrophenylmethylnitramine)	479-45-8	287.15	EPI
Thallium	7440-28-0	204.38	P
Toluene	108-88-3	92.14	EPI
Toxaphene	8001-35-2	413.82	EPI
Tribromomethane (Bromoform)	75-25-2	252.73	EPI
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	187.38	EPI
1,2,4-Trichlorobenzene	120-82-1	181.45	EPI
1,1,1-Trichloroethane	71-55-6	133.41	EPI
1,1,2-Trichloroethane	79-00-5	133.41	EPI
Trichloroethylene	79-01-6	131.39	EPI
Trichlorofluoromethane	75-69-4	137.37	EPI
2,4,5-Trichlorophenol	95-95-4	197.45	EPI
2,4,6-Trichlorophenol	88-06-2	197.45	EPI
1,1,2-Trichloropropane	598-77-6	147.43	EPI
1,2,3-Trichloropropane	96-18-4	147.43	EPI
Triethylamine	121-44-8	101.19	EPI
2,4,6-Trinitrotoluene	118-96-7	227.13	EPI
Uranium (soluable salts)	--	238.03	P
Vanadium	7440-62-2	50.94	EPI
Vinyl acetate	108-05-4	86.09	P
Vinyl bromide	593-60-2	106.95	EPI
Vinyl chloride	75-01-4	62.5	EPI
m-Xylene	108-38-3	106.17	EPI
o-Xylene	95-47-6	106.17	EPI
p-Xylene	106-42-3	110	EPI
Xylenes	1330-20-7	106.17	EPI
Zinc	7440-66-6	65.38	P
Petroleum Hydrocarbons[a]			
Aliphatics: C5 to C8	NA	93	

Chemical	CAS. NO.	MW (g/mole)	Ref.
C9 to C12	NA	149	
C9 to C18	NA	170	
C19 to C36	NA	280	
Aromatics: C9 to C10	NA	120	

EPI= US EPA. 2012. Estimation Programs Interface (EPI) Suite™ for Microsoft® Windows, v 4.11. Washington, DC, USA.
g/mole – grams per mole
P = periodic table of the elements
Ref – reference
ToxNet – Toxicological Data Network, US National Library of Medicine, http://chem.sis.nlm.nih.gov/chemidplus/rn/14797-73-0
[a]Chemical constants consistent with the approach presented in "Updated Petroleum Hydrocarbon Fraction Toxicity Values for the VPH/EPH/APH Methodology" MassDEP

Table B-2: Physical and Chemical Properties

Chemical	H (atm-m^3/mole)	Ref.	H' (unitless)	D_a (cm^2/s)	Ref.	D_w (cm^2/s)	Ref.	K_{oc} (cm^3/g)	Ref.	K_d (cm^3/g)	Ref.	S (mg/L-water)	Ref.	D_A (cm^2/s)	Res/Ind. VF (m^3/kg)	Comm/ VF (m^3/kg)	Solid	Soil SAT (mg/kg)	VOC
Acenaphthene	1.84E-04	EPI	7.54E-03	4.76E-02	W9	7.69E-06	W9	5.03E+03	EPI	7.54E+00	CALC	3.90E+00	EPI	4.91E-07			✔		✔
Acetaldehyde	6.67E-05	EPI	2.73E-03	1.24E-01	W9	1.41E-05	W9	1.00E+00	EPI	1.50E-03	CALC	1.00E+06	EPI	2.20E-05	2.65E+04	5.47E+03		1.75E+05	✔
Acetone	3.50E-05	EPI	1.44E-03	1.24E-01	W9	1.14E-05	W9	2.36E+00	EPI	3.55E-03	CALC	1.00E+06	EPI	1.23E-05	3.54E+04	7.31E+03		1.77E+05	✔
Acetophenone	1.04E-05	EPI	4.26E-04	6.00E-02	W9	8.73E-06	W9	5.19E+01	EPI	7.78E-02	CALC	6.13E+03	EPI	2.37E-06	8.07E+04	1.67E+04		1.54E+03	✔
Acrolein	1.22E-04	EPI	5.00E-03	1.05E-01	W9	1.22E-05	W9	1.00E+00	EPI	1.50E-03	CALC	2.12E+05	EPI	3.18E-05	2.20E+04	4.55E+03		3.72E+04	✔
Acrylonitrile	1.38E-04	EPI	5.66E-03	1.28E-01	W9	1.66E-05	W9	8.51E+00	EPI	1.28E-02	CALC	7.45E+04	EPI	4.11E-05	1.94E+04	4.00E+03		1.39E+04	✔
Alachlor	8.30E-09	EPI	3.40E-07	2.30E-02	W9	5.70E-06	W9	3.12E+02	EPI	4.68E-01	CALC	2.40E+02	EPI	3.53E-07					
Aldrin	4.40E-05	EPI	1.80E-03	1.96E-02	W9	4.86E-06	W9	8.20E+04	EPI	1.23E+02	CALC	1.70E-02	EPI	4.35E-09			✔		✔
Aluminum										1.50E+03	Baes								
Anthracene	5.56E-05	EPI	2.28E-03	3.85E-02	W9	7.74E-06	W9	1.64E+04	EPI	2.45E+01	CALC	4.34E-02	EPI	4.69E-08			✔		✔
Antimony										4.50E+01	SSG								
Arsenic										2.90E+01	SSG								
Atrazine	2.40E-09	EPI	9.84E-08	2.60E-02	W9	6.80E-06	W9	2.20E+02	EPI	3.30E-01	CALC	3.50E+01	EPI	5.37E-07					
Barium										4.10E+01	SSG								
Benzene	5.55E-03	EPI	2.28E-01	8.80E-02	W9	1.02E-05	W9	1.46E+02	EPI	2.19E-01	CALC	1.79E+03	EPI	4.65E-04	5.75E+03	1.19E+03		7.48E+02	✔
Benzidine	5.17E-11	EPI	2.12E-09	3.26E-02	W9	1.50E-05	W9	1.19E+03	EPI	1.79E+00	CALC	3.22E+02	EPI	3.04E-07					
Benzo(a)anthracene	1.20E-05	EPI	4.92E-04	5.10E-02	W9	9.00E-06	W9	1.77E+05	EPI	2.65E+02	CALC	9.40E-03	EPI	2.26E-09			✔		✔
Benzo(a)pyrene	4.57E-07	EPI	1.87E-05	4.30E-02	W9	9.00E-06	W9	5.87E+05	EPI	8.81E+02	CALC	1.62E-03	EPI	4.15E-10			✔		
Benzo(b)fluoranthene	6.57E-07	EPI	2.69E-05	2.23E-02	W9	5.56E-06	W9	5.99E+05	EPI	8.99E+02	CALC	1.50E-03	EPI	2.52E-10			✔		
Benzo(k)fluoranthene	5.84E-07	EPI	2.39E-05	2.23E-02	W9	5.56E-06	W9	5.87E+05	EPI	8.81E+02	CALC	8.00E-04	EPI	2.56E-10			✔		
Beryllium										7.90E+02	SSG								
a-BHC (HCH)	5.14E-06	EPI	2.11E-04	2.21E-02	W9	5.57E-06	W9	2.81E+03	EPI	4.21E+00	CALC	8.00E+00	EPI	6.08E-08			✔		
b-BHC (HCH)	5.14E-06	EPI	2.11E-04	2.21E-02	W9	5.57E-06	W9	2.81E+03	EPI	4.21E+00	CALC	8.00E+00	EPI	6.08E-08			✔		
g-BHC	5.10E-06	EPI	2.09E-04	2.75E-02	W9	7.34E-06	W9	2.81E+03	EPI	4.21E+00	CALC	8.00E+00	EPI	7.92E-08			✔		
1,1-Biphenyl	3.08E-04	EPI	1.26E-02	4.04E-02	W9	8.15E-06	W9	5.13E+03	EPI	7.69E+00	CALC	6.94E+00	EPI	6.70E-07			✔		✔
Bis(2-chloroethyl) ether	1.70E-05	EPI	6.97E-04	4.13E-02	W9	9.49E-06	W9	3.22E+01	EPI	4.83E-02	CALC	1.72E+04	EPI	2.96E-06	7.22E+04	1.49E+04		3.81E+03	✔
Bis(2-chloroisopropyl) ether	7.42E-05	EPI	3.04E-03	6.02E-02	W9	6.41E-06	W9	4.58E+01	EPI	6.87E-02	CALC	1.70E+03	EPI	8.37E-06	4.29E+04	8.86E+03		4.12E+02	✔
Bis(2-ethylhexyl) phthalate	2.70E-07	EPI	1.11E-05	3.51E-02	W9	3.66E-06	W9	1.20E+05	EPI	1.79E+02	CALC	2.70E-01	EPI	8.31E-10					
Bis(chloromethyl) ether	4.36E-03	EPI	1.79E-01	7.62E-02	W9	9.38E-06	W9	9.70E+00	EPI	1.45E-02	CALC	2.20E+04	EPI	6.36E-04	4.92E+03	1.02E+03		4.58E+03	✔
Boron										3.00E+00	Baes								
Bromodichloromethane	2.12E-03	EPI	8.69E-02	5.61E-02	W9	1.06E-05	W9	3.18E+01	EPI	4.77E-02	CALC	3.03E+03	EPI	2.06E-04	8.64E+03	1.78E+03		7.00E+02	✔
Bromomethane	7.34E-03	EPI	3.01E-01	7.28E-02	W9	1.21E-05	W9	1.32E+01	EPI	1.98E-02	CALC	1.52E+04	EPI	9.36E-04	4.06E+03	8.38E+02		3.45E+03	✔
1,3-Butadiene	7.36E-02	EPI	3.02E+00	2.49E-01	W9	1.08E-05	W9	3.96E+01	EPI	5.94E-02	CALC	7.35E+02	EPI	1.27E-02	1.10E+03	2.28E+02		4.22E+02	✔
2-Butanone (Methyl ethyl ketone, MEK)	5.69E-05	EPI	2.33E-03	8.08E-02	W9	9.80E-06	W9	4.51E+00	EPI	6.77E-03	CALC	2.23E+05	EPI	1.23E-05	3.54E+04	7.31E+03		4.02E+04	✔

Chemical	H (atm-m^3/mole)	Ref.	H' (unitless)	D_a (cm^2/s)	Ref.	D_w (cm^2/s)	Ref.	K_{oc} (cm^3/g)	Ref.	K_d (cm^3/g)	Ref.	S (mg/L-water)	Ref.	D_A (cm^2/s)	Res/Ind. VF (m^3/kg)	Comm/ VF (m^3/kg)	Solid	Soil SAT (mg/kg)	VOC
tert-Butyl methyl ether (MTBE)	5.87E-04	EPI	2.41E-02	8.59E-02	W9	1.01E-05	W9	1.16E+01	EPI	1.73E-02	CALC	5.10E+04	EPI	1.06E-04	1.21E+04	2.49E+03		9.86E+03	✔
Cadmium										7.50E+01	SSG								
Calcium																			
Carbofuran	3.10E-09	EPI	1.27E-07	2.60E-02	W9	6.60E-06	W9	9.50E+01	EPI	1.43E-01	CALC	3.20E+02	EPI	8.30E-07					
Carbon disulfide	1.44E-02	EPI	5.90E-01	1.04E-01	W9	1.00E-05	W9	2.17E+01	EPI	3.26E-02	CALC	2.16E+03	EPI	2.18E-03	2.66E+03	5.49E+02		5.89E+02	✔
Carbon tetrachloride	2.76E-02	EPI	1.13E+00	7.80E-02	W9	8.80E-06	W9	4.39E+01	EPI	6.58E-02	CALC	7.93E+02	EPI	2.33E-03	2.57E+03	5.31E+02		2.91E+02	✔
Chlordane	4.86E-05	EPI	1.99E-03	1.79E-02	W9	4.37E-06	W9	3.38E+04	EPI	5.07E+01	CALC	5.60E-02	EPI	1.02E-08			✔		✔
2-Chloroacetophenone	3.46E-06	EPI	1.42E-04	3.83E-02	W9	8.71E-06	W9	9.89E+01	EPI	1.48E-01	CALC	1.64E+03	EPI	1.24E-06					
2-Chloro-1,3-butadiene	5.61E-02	EPI	2.30E+00	1.04E-01	W9	1.00E-05	W9	6.07E+01	EPI	9.11E-02	CALC	8.75E+02	EPI	4.42E-03	1.87E+03	3.86E+02		4.59E+02	✔
1-Chloro-1,1-difluoroethane	5.88E-02	EPI	2.41E+00	7.69E-02	W9	9.54E-06	W9	4.39E+01	EPI	6.58E-02	CALC	1.40E+03	EPI	3.51E-03	2.10E+03	4.33E+02		7.17E+02	✔
Chlorobenzene	3.11E-03	EPI	1.28E-01	7.30E-02	W9	8.70E-06	W9	2.34E+02	EPI	3.51E-01	CALC	4.98E+02	EPI	1.68E-04	9.57E+03	1.98E+03		2.68E+02	✔
1-Chlorobutane	1.67E-02	EPI	6.85E-01	7.72E-02	W9	9.57E-06	W9	7.22E+01	EPI	1.08E-01	CALC	1.10E+03	EPI	1.43E-03	3.29E+03	6.79E+02		3.95E+02	✔
Chlorodifluoromethane	4.06E-02	EPI	1.66E+00	1.01E-01	W9	1.28E-05	W9	3.18E+01	EPI	4.77E-02	CALC	2.77E+03	EPI	3.99E-03	1.97E+03	4.06E+02		1.13E+03	✔
Chloroform	3.67E-03	EPI	1.50E-01	1.04E-01	W9	1.00E-05	W9	3.18E+01	EPI	4.77E-02	CALC	7.95E+03	EPI	6.39E-04	4.91E+03	1.01E+03		1.89E+03	✔
Chloromethane	8.82E-03	EPI	3.62E-01	1.26E-01	W9	6.50E-06	W9	1.32E+01	EPI	1.98E-02	CALC	5.32E+03	EPI	1.89E-03	2.86E+03	5.90E+02		1.25E+03	✔
b-Chloronaphthalene	3.20E-04	EPI	1.31E-02	4.92E-02	W9	8.79E-06	W9	2.48E+03	EPI	3.72E+00	CALC	1.17E+01	EPI	1.70E-06			✔		✔
o-Chloronitrobenzene	9.30E-06	EPI	3.81E-04	5.37E-02	W9	9.37E-06	W9	3.71E+02	EPI	5.56E-01	CALC	4.41E+02	EPI	7.83E-07					
p-Chloronitrobenzene	4.89E-06	EPI	2.00E-04	5.01E-02	W9	8.52E-06	W9	3.63E+02	EPI	5.45E-01	CALC	2.25E+02	EPI	6.07E-07					
2-Chlorophenol	1.12E-05	EPI	4.59E-04	6.60E-02	W9	9.46E-06	W9	3.07E+02	EPI	4.60E-01	CALC	2.85E+04	EPI	1.06E-06	1.21E+05	2.49E+04		1.80E+04	✔
2-Chloropropane	1.75E-02	EPI	7.18E-01	8.88E-02	W9	1.01E-05	W9	3.18E+01	EPI	4.77E-02	CALC	3.10E+03	EPI	2.04E-03	2.75E+03	5.67E+02		9.37E+02	✔
o-Chlorotoluene	3.57E-03	EPI	1.46E-01	6.28E-02	W9	8.70E-06	W9	3.83E+02	EPI	5.74E-01	CALC	3.74E+02	EPI	1.17E-04	1.15E+04	2.37E+03		2.86E+02	✔
Chromium III										1.80E+06	SSG								
Chromium VI										1.90E+01	SSG								
Chromium (Total)										1.80E+06	SSG								
Chrysene	5.23E-06	EPI	2.14E-04	2.44E-02	W9	6.21E-06	W9	1.81E+05	EPI	2.71E+02	CALC	2.00E-03	EPI	1.10E-09			✔		
Cobalt										4.50E+01	Baes								
Copper										3.50E+01	Baes								
Crotonaldehyde	1.94E-05	EPI	7.95E-04	1.02E-01	W9	1.18E-05	W9	1.79E+00	EPI	2.69E-03	CALC	1.81E+05	EPI	7.14E-06	4.64E+04	9.59E+03		3.19E+04	✔
Cumene (isopropylbenzene)	1.15E-02	EPI	4.72E-01	6.50E-02	W9	7.10E-06	W9	6.98E+02	EPI	1.05E+00	CALC	6.13E+01	EPI	2.33E-04	8.12E+03	1.68E+03		7.81E+01	✔
Cyanide	1.33E-04	EPI	5.45E-03	1.56E-01	W9	1.77E-05	W9	2.84E+00	EPI	4.26E-03	CALC	1.00E+06	EPI	5.01E-05	1.75E+04	3.62E+03		1.78E+05	✔
Cyanogen	5.40E-03	EPI	2.21E-01	1.23E-01	W9	1.37E-05	W9	1.83E+00	EPI	2.74E-03	CALC	1.19E+08	EPI	1.32E-03			✔		✔
Cyanogen bromide	2.45E-02	EPI	1.00E+00	7.32E-02	W9	9.25E-06	W9	4.67E+00	EPI	7.01E-03	CALC	1.08E+05	EPI	2.42E-03			✔		✔
Cyanogen chloride	2.45E-02	EPI	1.00E+00	1.29E-01	W9	1.57E-05	W9	4.67E+00	EPI	7.01E-03	CALC	1.58E+05	EPI	4.28E-03			✔		✔
DDD	6.60E-06	EPI	2.71E-04	2.27E-02	W9	5.79E-06	W9	1.18E+05	EPI	1.76E+02	CALC	9.00E-02	EPI	1.64E-09			✔		
DDE	4.16E-05	EPI	1.71E-03	2.38E-02	W9	5.87E-06	W9	1.18E+05	EPI	1.76E+02	CALC	4.00E-02	EPI	3.55E-09			✔		1
DDT	8.32E-06	EPI	3.41E-04	1.99E-02	W9	4.95E-06	W9	1.69E+05	EPI	2.53E+02	CALC	5.50E-03	EPI	1.04E-09			✔		
Dibenz(a,h)anthracene	1.41E-07	EPI	5.78E-06	2.11E-02	W9	5.24E-06	W9	1.91E+06	EPI	2.87E+03	CALC	1.03E-03	EPI	7.30E-11			✔		

Chemical	H (atm-m^3/mole)	Ref.	H' (unitless)	D_a (cm^2/s)	Ref.	D_w (cm^2/s)	Ref.	K_{oc} (cm^3/g)	Ref.	K_d (cm^3/g)	Ref.	S (mg/L-water)	Ref.	D_A (cm^2/s)	Res/Ind. VF (m^3/kg)	Comm/ VF (m^3/kg)	Solid	Soil SAT (mg/kg)	VOC
1,2-Dibromo-3-chloropropane	1.47E-04	EPI	6.03E-03	2.68E-02	W9	7.02E-06	W9	1.16E+02	EPI	1.74E-01	CALC	1.23E+03	EPI	5.30E-06	5.39E+04	1.11E+04		4.28E+02	✔
Dibromochloromethane	7.83E-04	EPI	3.21E-02	3.66E-02	W9	1.05E-05	W9	3.18E+01	EPI	4.77E-02	CALC	2.70E+03	EPI	5.25E-05	1.71E+04	3.54E+03		6.07E+02	✔
1,2-Dibromoethane	6.50E-04	EPI	2.67E-02	4.30E-02	W9	8.44E-06	W9	3.96E+01	EPI	5.94E-02	CALC	3.91E+03	EPI	4.85E-05	1.78E+04	3.68E+03		9.22E+02	✔
1,4-Dichloro-2-butene	6.64E-04	EPI	2.72E-02	7.25E-02	W9	8.12E-06	W9	1.32E+02	EPI	1.97E-01	CALC	5.80E+02	EPI	5.21E-05	1.72E+04	3.55E+03		2.17E+02	✔
1,2-Dichlorobenzene	1.92E-03	EPI	7.87E-02	6.90E-02	W9	7.90E-06	W9	3.83E+02	EPI	5.74E-01	CALC	8.00E+01	EPI	7.00E-05	1.48E+04	3.06E+03		6.05E+01	✔
1,4-Dichlorobenzene	2.41E-03	EPI	9.88E-02	6.90E-02	W9	7.90E-06	W9	3.75E+02	EPI	5.63E-01	CALC	8.13E+01	EPI	8.88E-05			✔		✔
3,3-Dichlorobenzidine	2.84E-11	EPI	1.16E-09	2.59E-02	W9	6.74E-06	W9	3.19E+03	EPI	4.79E+00	CALC	3.10E+00	EPI	5.40E-08			✔		
Dichlorodifluoromethane	3.43E-01	EPI	1.41E+01	6.65E-02	W9	9.92E-06	W9	4.39E+01	EPI	6.58E-02	CALC	2.80E+02	EPI	4.94E-03	1.77E+03	3.65E+02		5.13E+02	✔
1,1-Dichloroethane	5.62E-03	EPI	2.30E-01	7.42E-02	W9	1.05E-05	W9	3.18E+01	EPI	4.77E-02	CALC	5.04E+03	EPI	6.72E-04	4.79E+03	9.89E+02		1.25E+03	✔
1,2-Dichloroethane	1.18E-03	EPI	4.84E-02	1.04E-01	W9	9.90E-06	W9	3.96E+01	EPI	5.94E-02	CALC	5.10E+03	EPI	2.06E-04	8.64E+03	1.78E+03		1.21E+03	✔
cis-1,2-Dichloroethene	4.08E-03	EPI	1.67E-01	8.86E-02	W9	1.13E-05	W9	3.96E+01	EPI	5.94E-02	CALC	3.50E+03	EPI	5.72E-04	5.19E+03	1.07E+03		8.81E+02	✔
trans-1,2-Dichloroethene	4.08E-03	EPI	1.67E-01	7.03E-02	W9	1.19E-05	W9	3.96E+01	EPI	5.94E-02	CALC	3.50E+03	EPI	4.55E-04	5.82E+03	1.20E+03		8.81E+02	✔
1,1-Dichloroethene	2.61E-02	EPI	1.07E+00	9.00E-02	W9	1.04E-05	W9	3.18E+01	EPI	4.77E-02	CALC	2.42E+03	EPI	2.73E-03	2.38E+03	4.91E+02		8.28E+02	✔
2,4-Dichlorophenol	4.29E-06	EPI	1.76E-04	4.89E-02	W9	8.77E-06	W9	4.92E+02	EPI	7.38E-01	CALC	4.50E+03	EPI	4.74E-07					
1,2-Dichloropropane	2.82E-03	EPI	1.16E-01	7.82E-02	W9	8.73E-06	W9	6.07E+01	EPI	9.11E-02	CALC	2.80E+03	EPI	3.17E-04	6.97E+03	1.44E+03		7.77E+02	✔
1,3-Dichloropropene	3.55E-03	EPI	1.46E-01	6.26E-02	W9	1.00E-05	W9	7.22E+01	EPI	1.08E-01	CALC	2.80E+03	EPI	2.98E-04	7.20E+03	1.49E+03		8.35E+02	✔
Dicyclopentadiene	6.25E-02	EPI	2.56E+00	5.57E-02	W9	7.75E-06	W9	1.51E+03	EPI	2.27E+00	CALC	5.19E+01	EPI	5.06E-04			✔		✔
Dieldrin	1.00E-05	EPI	4.10E-04	1.92E-02	W9	4.74E-06	W9	2.01E+04	EPI	3.01E+01	CALC	2.50E-01	EPI	8.73E-09			✔		
Diethyl phthalate	6.10E-07	EPI	2.50E-05	2.49E-02	W9	6.35E-06	W9	1.05E+02	EPI	1.57E-01	CALC	1.08E+03	EPI	7.81E-07					
Di-n-butyl phthalate (Dibutyl phthalate)	1.81E-06	EPI	7.42E-05	4.38E-02	W9	7.86E-06	W9	1.16E+03	EPI	1.74E+00	CALC	1.12E+01	EPI	1.80E-07					
2,4-Dimethylphenol	9.51E-07	EPI	3.90E-05	6.43E-02	W9	8.69E-06	W9	4.92E+02	EPI	7.38E-01	CALC	7.87E+03	EPI	4.06E-07			✔		
Dimethyl phthalate	3.19E-13	EPI	1.31E-11	4.90E-02	W9	9.00E-06	W9	7.90E+01	EPI	1.19E-01	CALC	1.50E+01	EPI	1.23E-06					
4,6-Dinitro-o-cresol	1.40E-06	EPI	5.74E-05	2.76E-02	W9	6.91E-06	W9	7.54E+02	EPI	1.13E+00	CALC	1.98E+02	EPI	2.22E-07					
2,4-Dinitrophenol	8.60E-08	EPI	3.53E-06	2.73E-02	W9	9.06E-06	W9	4.61E+02	EPI	6.91E-01	CALC	2.79E+03	EPI	4.17E-07			✔		
2,4-Dinitrotoluene	5.40E-08	EPI	2.21E-06	2.03E-01	W9	7.06E-06	W9	5.76E+02	EPI	8.63E-01	CALC	2.00E+02	EPI	2.75E-07			✔		
2,6-Dintitrotoluene	7.47E-07	EPI	3.06E-05	3.70E-02	W9	7.76E-06	W9	5.87E+02	EPI	8.81E-01	CALC	3.52E+02	EPI	3.03E-07			✔		
2,4/2,6-Dintrotoluene Mixture	9.26E-08	EPI	3.80E-06	3.75E-02	W9	7.89E-06	W9	5.87E+02	EPI	8.81E-01	CALC	2.70E+02	EPI	2.99E-07					
1,4-Dioxane	4.80E-06	EPI	1.97E-04	2.29E-01	W9	1.02E-05	W9	2.63E+00	EPI	3.95E-03	CALC	1.00E+06	EPI	4.75E-06					
1,2-Diphenylhydrazine	4.78E-07	EPI	1.96E-05	3.47E-02	W9	7.36E-06	W9	1.51E+03	EPI	2.26E+00	CALC	2.21E+02	EPI	1.23E-07					
Endosulfan	6.50E-05	EPI	2.67E-03	1.85E-02	W9	4.55E-06	W9	6.76E+03	EPI	1.01E+01	CALC	4.50E-01	EPI	6.38E-08			✔		✔
Endrin	1.00E-05	EPI	4.10E-04	1.92E-02	W9	4.74E-06	W9	2.01E+04	EPI	3.01E+01	CALC	2.50E-01	EPI	8.73E-09			✔		
Epichlorohydrin	3.04E-05	EPI	1.25E-03	8.60E-02	W9	9.80E-06	W9	9.91E+00	EPI	1.49E-02	CALC	6.59E+04	EPI	7.58E-06	4.51E+04	9.31E+03		1.24E+04	✔
Ethyl acetate	1.34E-04	EPI	5.49E-03	7.32E-02	W9	9.70E-06	W9	5.58E+00	EPI	8.37E-03	CALC	8.00E+04	EPI	2.35E-05	2.56E+04	5.29E+03		1.46E+04	✔
Ethyl acrylate	3.39E-04	EPI	1.39E-02	7.70E-02	W9	8.60E-06	W9	1.07E+01	EPI	1.60E-02	CALC	1.50E+04	EPI	5.61E-05	1.66E+04	3.42E+03		2.86E+03	✔
Ethyl chloride	1.11E-02	EPI	4.55E-01	2.71E-01	W9	1.15E-05	W9	2.17E+01	EPI	3.26E-02	CALC	6.71E+03	EPI	4.64E-03	1.82E+03	3.76E+02		1.73E+03	✔
Ethyl ether	1.23E-03	EPI	5.04E-02	7.82E-02	W9	8.61E-06	W9	9.70E+00	EPI	1.45E-02	CALC	6.04E+04	EPI	1.99E-04	8.79E+03	1.82E+03		1.17E+04	✔
Ethyl methacrylate	5.73E-04	EPI	2.35E-02	6.53E-02	W9	8.37E-06	W9	1.67E+01	EPI	2.50E-02	CALC	5.40E+03	EPI	7.56E-05	1.43E+04	2.95E+03		1.09E+03	✔

Chemical	H (atm-m^3/mole)	Ref.	H' (unitless)	D_a (cm^2/s)	Ref.	D_w (cm^2/s)	Ref.	K_{oc} (cm^3/g)	Ref.	K_d (cm^3/g)	Ref.	S (mg/L-water)	Ref.	D_A (cm^2/s)	Res/Ind. VF (m^3/kg)	Comm/ VF (m^3/kg)	Solid	Soil SAT (mg/kg)	VOC
Ethylbenzene	7.88E-03	EPI	3.23E-01	7.50E-02	W9	7.80E-06	W9	4.46E+02	EPI	6.69E-01	CALC	1.69E+02	EPI	2.67E-04	7.59E+03	1.57E+03		1.49E+02	✔
Ethylene oxide	1.48E-04	EPI	6.07E-03	1.04E-01	W9	1.45E-05	W9	3.24E+00	EPI	4.86E-03	CALC	1.00E+06	EPI	3.74E-05	2.03E+04	4.19E+03		1.79E+05	✔
Fluoranthene	8.86E-06	EPI	3.63E-04	2.51E-02	W9	6.35E-06	W9	5.55E+04	EPI	8.32E+01	CALC	2.60E-01	EPI	4.09E-09			✔		
Fluorene	9.62E-05	EPI	3.94E-03	4.40E-02	W9	7.88E-06	W9	9.16E+03	EPI	1.37E+01	CALC	1.69E+00	EPI	1.43E-07			✔		✔
Fluoride										1.50E+02	Baes								
Furan	5.40E-03	EPI	2.21E-01	1.04E-01	W9	1.22E-05	W9	8.00E+01	EPI	1.20E-01	CALC	1.00E+04	EPI	7.02E-04	4.68E+03	9.68E+02		3.18E+03	✔
Gylphosate	2.10E-12	EPI	8.61E-11	6.20E-02	W9	7.30E-06	W9	2.10E+03	SSL	3.15E+00	CALC	1.10E+04	EPI	8.73E-08					
Heptachlor	2.94E-04	EPI	1.21E-02	2.23E-02	W9	5.69E-06	W9	4.13E+04	EPI	6.19E+01	CALC	1.80E-01	EPI	4.56E-08			✔		✔
Hexachlorobenzene	1.70E-03	EPI	6.97E-02	5.42E-02	W9	5.91E-06	W9	6.20E+03	EPI	9.29E+00	CALC	6.20E-03	EPI	3.89E-06			✔		✔
Hexachloro-1,3-butadiene	1.03E-02	EPI	4.22E-01	5.61E-02	W9	6.16E-06	W9	8.45E+02	EPI	1.27E+00	CALC	3.20E+00	EPI	1.54E-04	9.99E+03	2.06E+03		4.76E+00	✔
Hexachlorocyclopentadiene	2.70E-02	EPI	1.11E+00	2.79E-02	W9	7.21E-06	W9	1.40E+03	EPI	2.11E+00	CALC	1.80E+00	EPI	1.25E-04	1.11E+04	2.30E+03		4.33E+00	✔
Hexachloroethane	3.89E-03	EPI	1.59E-01	2.50E-03	W9	6.80E-06	W9	1.97E+02	EPI	2.95E-01	CALC	5.00E+01	EPI	8.50E-06			✔		✔
n-Hexane	1.80E+00	EPI	7.38E+01	2.00E-01	W9	7.77E-06	W9	1.32E+02	EPI	1.97E-01	CALC	9.50E+00	EPI	1.64E-02	9.70E+02	2.00E+02		8.30E+01	✔
HMX	8.67E-10	EPI	3.55E-08	2.69E-02	W9	7.15E-06	W9	5.32E+02	EPI	7.97E-01	CALC	9.44E+03	EPI	2.93E-07					
Hydrazine anhydride	6.10E-07	SSG	2.50E-05	1.70E-01	W9	1.90E-05	W9	1.60E-02	EPI	2.39E-05	CALC	1.00E+06	EPI	4.68E-06	5.74E+04	1.19E+04		1.73E+05	✔
Hydrogen cyanide	1.33E-04	EPI	5.45E-03	1.97E-01	W9	1.82E-05	W9	2.84E+00	EPI	4.26E-03	CALC	1.00E+06	EPI	6.25E-05	1.57E+04	3.24E+03		1.78E+05	✔
Indeno(1,2,3-c,d)pyrene	3.48E-07	EPI	1.43E-05	2.25E-02	W9	5.66E-06	W9	1.95E+06	EPI	2.93E+03	CALC	1.90E-04	EPI	7.79E-11			✔		
Iron										2.50E+01	Baes								
Isobutanol (Isobutyl alcohol)	9.78E-06	EPI	4.01E-04	8.60E-02	W9	9.30E-06	W9	2.92E+00	EPI	4.38E-03	CALC	8.50E+04	EPI	3.96E-06			✔		
Isophorone	6.64E-06	EPI	2.72E-04	6.23E-02	W9	6.76E-06	W9	6.52E+01	EPI	9.77E-02	CALC	1.20E+04	EPI	1.60E-06					
Lead										9.00E+02	Baes								
Lead (tetraethyl-)	5.68E-01	EPI	2.33E+01	2.46E-02	W9	6.40E-06	W9	6.48E+02	EPI	9.72E-01	CALC	2.90E-01	EPI	1.47E-03	3.24E+03	6.69E+02		1.10E+00	✔
Maleic hydrazide	2.65E-11	EPI	1.09E-09	5.81E-02	W9	8.14E-06	W9	3.30E+00	EPI	4.95E-03	CALC	4.51E+03	EPI	1.81E-06					
Manganese										6.50E+01	Baes								
Mercury (elemental)	1.14E-02	SSG	4.67E-01	3.07E-02	SSG	6.30E-06	SSG			5.20E+01	SSG	6.00E-02	EPI	2.67E-06	7.60E+04	1.57E+04		3.13E+00	✔
Mercury (methyl)								1.32E+01	EPI	1.98E-02	CALC	3.13E+04	EPI						
Mercury Chloride (Mercury Salts)										5.20E+01	Baes								
Methacrylonitrile	2.47E-04	EPI	1.01E-02	1.12E-01	W9	1.32E-05	W9	1.31E+01	EPI	1.96E-02	CALC	2.54E+04	EPI	5.95E-05	1.61E+04	3.32E+03		4.93E+03	✔
Methomyl	1.97E-11	EPI	8.08E-10	2.84E-02	W9	6.47E-06	W9	1.00E+01	EPI	1.50E-02	CALC	5.80E+04	EPI	1.36E-06					
Methyl acetate	1.15E-04	EPI	4.72E-03	9.57E-02	W9	1.10E-05	W9	3.06E+00	EPI	4.60E-03	CALC	2.43E+05	EPI	2.70E-05	2.39E+04	4.94E+03		4.34E+04	✔
Methyl acrylate	1.99E-04	EPI	8.16E-03	8.66E-02	W9	1.02E-05	W9	5.84E+00	EPI	8.77E-03	CALC	4.94E+04	EPI	3.96E-05	1.97E+04	4.07E+03		9.04E+03	✔
Methyl isobutyl ketone	1.38E-04	EPI	5.66E-03	7.50E-02	W9	7.80E-06	W9	1.26E+01	EPI	1.89E-02	CALC	1.90E+04	EPI	2.29E-05	2.59E+04	5.35E+03		3.66E+03	✔
Methyl methacrylate	3.19E-04	EPI	1.31E-02	7.70E-02	W9	8.60E-06	W9	9.14E+00	EPI	1.37E-02	CALC	1.50E+04	EPI	5.36E-05	1.70E+04	3.50E+03		2.83E+03	✔
Methyl styrene (alpha)	2.55E-03	EPI	1.05E-01	2.64E-01	W9	1.14E-05	W9	6.98E+02	EPI	1.05E+00	CALC	8.90E+01	EPI	2.18E-04	8.42E+03	1.74E+03		1.10E+02	✔
Methyl styrene (mixture)	3.05E-03	EPI	1.25E-01	6.55E-02	W9	8.66E-06	W9	7.16E+02	EPI	1.07E+00	CALC	8.90E+01	EPI	6.32E-05	1.56E+04	3.22E+03		1.12E+02	✔
Methylcyclohexane	4.30E-01	EPI	1.76E+01	7.35E-02	W9	8.52E-06	W9	2.34E+02	EPI	3.51E-01	CALC	1.40E+01	EPI	4.98E-03	1.76E+03	3.63E+02		3.53E+01	✔
Methylene bromide (Dibromomethane)	8.22E-04	EPI	3.37E-02	4.30E-02	W9	8.44E-06	W9	2.17E+01	EPI	3.26E-02	CALC	1.19E+04	EPI	6.86E-05	1.50E+04	3.10E+03		2.50E+03	✔

Chemical	H (atm-m^3/mole)	Ref.	H' (unitless)	D_a (cm^2/s)	Ref.	D_w (cm^2/s)	Ref.	K_{oc} (cm^3/g)	Ref.	K_d (cm^3/g)	Ref.	S (mg/L-water)	Ref.	D_A (cm^2/s)	Res/Ind. VF (m^3/kg)	Comm/ VF (m^3/kg)	Solid	Soil SAT (mg/kg)	VOC
Methylene chloride	3.25E-03	EPI	1.33E-01	1.01E-01	W9	1.17E-05	W9	2.17E+01	EPI	3.26E-02	CALC	1.30E+04	EPI	5.92E-04	5.10E+03	1.05E+03		2.87E+03	✔
1-Methylnaphthalene	5.10E-04	EPI	2.09E-02	5.30E-02	W9	7.80E-06	W9	2.50E+03	EPI	3.75E+00	CALC	2.60E+01	EPI	2.81E-06	7.40E+04	1.53E+04		1.02E+02	✔
2-Methylnaphthalene	5.20E-04	EPI	2.13E-02	5.20E-02	W9	7.80E-06	W9	2.50E+03	EPI	3.75E+00	CALC	2.50E+01	EPI	2.82E-06	7.40E+04	1.53E+04		9.81E+01	✔
Molybdenum										2.00E+01	Baes								
Naphthalene	4.40E-04	EPI	1.80E-02	5.90E-02	W9	7.50E-06	W9	1.54E+03	EPI	2.32E+00	CALC	3.10E+01	EPI	4.26E-06			✔		✔
Nickel										6.50E+01	SSG								
Nitrate										5.00E-01	Baes								
Nitrite										5.00E-01	Baes								
Nitrobenzene	2.40E-05	EPI	9.84E-04	7.60E-02	W9	8.60E-06	W9	2.26E+02	EPI	3.40E-01	CALC	2.09E+03	EPI	2.08E-06	8.61E+04	1.78E+04		1.07E+03	✔
Nitroglycerin	8.66E-08	EPI	3.55E-06	2.90E-02	W9	7.76E-06	W9	1.16E+02	EPI	1.74E-01	CALC	1.38E+03	EPI	8.91E-07					
Nitrophenol																			
N-Nitrosodiethylamine	3.63E-06	EPI	1.49E-04	7.65E-02	W9	9.51E-06	W9	8.29E+01	EPI	1.24E-01	CALC	1.06E+05	EPI	1.64E-06					
N-Nitrosodimethylamine	1.82E-06	EPI	7.46E-05	1.04E-01	W9	1.00E-05	W9	2.28E+01	EPI	3.42E-02	CALC	1.00E+06	EPI	2.28E-06					
N-Nitrosodi-*n*-butylamine	1.32E-05	EPI	5.41E-04	4.42E-02	W9	7.27E-06	W9	9.15E+02	EPI	1.37E+00	CALC	1.27E+03	EPI	3.37E-07	2.14E+05	4.42E+04	✔		✔
N-Nitrosodiphenylamine	1.21E-06	EPI	4.96E-05	2.83E-02	W9	7.19E-06	W9	2.63E+03	EPI	3.95E+00	CALC	3.50E+01	EPI	7.26E-08			✔		
N-Nitrosopyrrolidine	4.89E-08	EPI	2.00E-06	8.20E-02	W9	1.04E-05	W9	9.19E+01	EPI	1.38E-01	CALC	1.00E+06	EPI	1.33E-06					
m-Nitrotoluene	9.30E-06	EPI	3.81E-04	5.86E-02	W9	8.64E-06	W9	3.63E+02	EPI	5.45E-01	CALC	5.00E+02	EPI	7.79E-07					
o-Nitrotoluene	1.25E-05	EPI	5.13E-04	5.87E-02	W9	8.67E-06	W9	3.71E+02	EPI	5.56E-01	CALC	6.50E+02	EPI	8.72E-07	1.33E+05	2.75E+04		4.74E+02	✔
p-Nitrotoluene	5.63E-06	EPI	2.31E-04	5.85E-02	W9	8.61E-06	W9	3.63E+02	EPI	5.45E-01	CALC	4.42E+02	EPI	6.59E-07					
Pentachlorobenzene	7.03E-04	EPI	2.88E-02	5.70E-02	W9	6.30E-06	W9	3.71E+03	EPI	5.56E+00	CALC	8.31E-01	EPI	2.82E-06	7.39E+04	1.53E+04		4.77E+00	✔
Pentachlorophenol	2.45E-08	EPI	1.00E-06	5.60E-02	W9	6.10E-06	W9	4.96E+03	EPI	7.44E+00	CALC	1.40E+01	EPI	3.19E-08			✔		
Perchlorate										2.50E-01	Baes								
Perfluorinate chemicals (PFCs)																			
Perfluorohexane sulfonic acid (PFHxS)																			
Perfluorooctane sulfonate (PFO, PFOS)																			
Perfluorooctanoic acid (PFOA)																			
Phenanthrene	4.23E-05	EPI	1.73E-03	3.75E-02	W9	7.47E-06	W9	1.67E+04	EPI	2.50E+01	CALC	1.15E+00	EPI	3.68E-08			✔		✔
Phenol	3.33E-07	EPI	1.37E-05	8.20E-02	W9	9.10E-06	W9	1.87E+02	EPI	2.81E-01	CALC	8.28E+04	EPI	8.20E-07			✔		
Polychlorinatedbiphenyls																			
Aroclor 1016	2.00E-04	EPI	8.20E-03	3.25E-02	W9	7.26E-06	W9	4.77E+04	EPI	7.16E+01	CALC	4.20E-01	EPI	4.00E-08	6.20E+05	1.28E+05		3.01E+01	✔
Aroclor 1221	7.36E-04	EPI	3.02E-02	3.25E-02	W9	7.26E-06	W9	8.40E+03	EPI	1.26E+01	CALC	1.45E+00	EPI	7.67E-07	1.42E+05	2.93E+04		1.85E+01	✔
Aroclor 1232	7.36E-04	EPI	3.02E-02	2.56E-02	W9	6.56E-06	W9	8.40E+03	EPI	1.26E+01	CALC	1.45E+00	EPI	6.07E-07	1.59E+05	3.29E+04		1.85E+01	✔
Aroclor 1242	1.90E-04	EPI	7.79E-03	2.37E-02	W9	6.02E-06	W9	7.81E+04	EPI	1.17E+02	CALC	2.77E-01	EPI	1.73E-08	9.43E+05	1.95E+05		3.25E+01	✔
Aroclor 1248	4.40E-04	EPI	1.80E-02	2.16E-02	W9	5.50E-06	W9	7.65E+04	EPI	1.15E+02	CALC	1.00E-01	EPI	3.48E-08	6.65E+05	1.37E+05		1.15E+01	✔
Aroclor 1254	2.83E-04	EPI	1.16E-02	2.02E-02	W9	5.00E-06	W9	1.31E+05	EPI	1.96E+02	CALC	3.40E-03	EPI	1.26E-08	1.11E+06	2.28E+05		6.66E-01	✔
Aroclor 1260	3.36E-04	EPI	1.38E-02	2.28E-02	W9	5.83E-06	W9	3.50E+05	EPI	5.25E+02	CALC	1.14E-02	EPI	6.24E-09	1.57E+06	3.25E+05		6.00E+00	✔
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	9.00E-06	EPI	3.69E-04	1.78E-02	W9	4.19E-06	W9	3.57E+05	EPI	5.35E+02	CALC	3.47E-03	EPI	4.30E-10					

Chemical	H (atm-m^3/mole)	Ref.	H' (unitless)	D_a (cm^2/s)	Ref.	D_w (cm^2/s)	Ref.	K_{oc} (cm^3/g)	Ref.	K_d (cm^3/g)	Ref.	S (mg/L-water)	Ref.	D_A (cm^2/s)	Res/Ind. VF (m^3/kg)	Comm/ VF (m^3/kg)	Solid	Soil SAT (mg/kg)	VOC
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	1.00E-05	EPI	4.10E-04	1.78E-02	W9	4.19E-06	W9	3.50E+05	EPI	5.25E+02	CALC	3.85E-03	EPI	4.52E-10					
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	5.07E-05	EPI	2.08E-03	1.78E-02	W9	4.19E-06	W9	3.50E+05	EPI	5.25E+02	CALC	7.53E-04	EPI	9.99E-10	3.93E+06	8.11E+05		3.95E-01	✔
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	6.85E-05	EPI	2.81E-03	1.82E-02	W9	4.43E-06	W9	2.09E+05	EPI	3.14E+02	CALC	2.23E-03	EPI	2.14E-09	2.68E+06	5.55E+05		7.00E-01	✔
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	6.85E-05	EPI	2.81E-03	1.82E-02	W9	4.43E-06	W9	2.14E+05	EPI	3.20E+02	CALC	1.72E-03	EPI	2.09E-09	2.71E+06	5.60E+05		5.52E-01	✔
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	1.43E-04	EPI	5.86E-03	1.82E-02	W9	4.43E-06	W9	2.14E+05	EPI	3.20E+02	CALC	5.33E-03	EPI	3.78E-09	2.02E+06	4.17E+05		1.71E+00	✔
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	6.85E-05	EPI	2.81E-03	1.82E-02	W9	4.43E-06	W9	2.09E+05	EPI	3.14E+02	CALC	5.10E-04	EPI	2.14E-09	2.68E+06	5.55E+05		1.60E-01	✔
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	9.24E-05	EPI	3.79E-03	1.92E-02	W9	4.70E-06	W9	1.31E+05	EPI	1.96E+02	CALC	1.60E-02	EPI	4.55E-09	1.84E+06	3.80E+05		3.13E+00	✔
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	2.88E-04	EPI	1.18E-02	1.92E-02	W9	4.70E-06	W9	1.28E+05	EPI	1.92E+02	CALC	1.34E-02	EPI	1.24E-08	1.11E+06	2.30E+05		2.57E+00	✔
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	2.83E-04	EPI	1.16E-02	1.92E-02	W9	4.70E-06	W9	1.31E+05	EPI	1.96E+02	CALC	3.40E-03	EPI	1.20E-08	1.13E+06	2.34E+05		6.66E-01	✔
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	9.24E-05	EPI	3.79E-03	1.92E-02	W9	4.70E-06	W9	1.31E+05	EPI	1.96E+02	CALC	1.60E-02	EPI	4.55E-09	1.84E+06	3.80E+05		3.13E+00	✔
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	9.24E-05	EPI	3.79E-03	1.92E-02	W9	4.70E-06	W9	1.28E+05	EPI	1.92E+02	CALC	9.39E-03	EPI	4.64E-09	1.82E+06	3.76E+05		1.80E+00	✔
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	9.40E-06	EPI	3.85E-04	2.04E-02	W9	5.03E-06	W9	7.81E+04	EPI	1.17E+02	CALC	5.69E-04	EPI	2.35E-09					
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	1.25E-04	EPI	5.13E-03	2.04E-02	W9	5.03E-06	W9	7.81E+04	EPI	1.17E+02	CALC	5.32E-02	EPI	1.03E-08	1.22E+06	2.52E+05		6.24E+00	✔
Propylene oxide	6.96E-05	EPI	2.85E-03	1.04E-01	W9	1.00E-05	W9	5.19E+00	EPI	7.79E-03	CALC	5.90E+05	EPI	1.80E-05	2.92E+04	6.04E+03		1.07E+05	✔
Pyrene	1.19E-05	EPI	4.88E-04	2.77E-02	W9	7.24E-06	W9	5.43E+04	EPI	8.15E+01	CALC	1.35E-01	EPI	5.12E-09			✔		✔
RDX	2.00E-11	EPI	8.20E-10	3.11E-02	W9	8.49E-06	W9	8.91E+01	EPI	1.34E-01	CALC	5.97E+01	EPI	1.10E-06					
Selenium										5.00E+00	SSG								
Silver										8.30E+00	SSG								
Simazine	9.40E-10	EPI	3.85E-08	2.80E-02	W9	7.40E-06	W9	1.50E+02	EPI	2.25E-01	CALC	6.20E+00	EPI	7.38E-07					
Strontium										3.50E+01	Baes								
Styrene	2.75E-03	EPI	1.13E-01	7.10E-02	W9	8.00E-06	W9	4.46E+02	EPI	6.69E-01	CALC	3.10E+02	EPI	9.11E-05	1.30E+04	2.69E+03		2.65E+02	✔
Sulfolane	4.85E-06	EPI	1.99E-04	7.13E-02	W9	9.85E-06	W9	9.08E+00	EPI	1.36E-02	CALC	2.93E+05	EPI	2.83E-06					
2,3,7,8-TCDD	5.00E-05	EPI	2.05E-03	1.04E-01	W9	5.60E-06	W9	2.49E+05	EPI	3.74E+02	CALC	2.00E-04	EPI	6.12E-09	1.59E+06	3.28E+05		7.48E-02	✔
2,3,7,8-TCDF	1.67E-05	EPI	6.85E-04	2.35E-02	W9	6.10E-06	W9	1.40E+05	EPI	2.09E+02	CALC	6.92E-04	EPI	1.90E-09	2.85E+06	5.88E+05		1.45E-01	✔
1,2,4,5-Tetrachlorobenzene	1.00E-03	EPI	4.10E-02	3.19E-02	W9	8.75E-06	W9	2.22E+03	EPI	3.33E+00	CALC	5.95E-01	EPI	3.71E-06	6.44E+04	1.33E+04		2.09E+00	✔
1,1,1,2-Tetrachloroethane	2.50E-03	EPI	1.03E-01	7.10E-02	W9	7.90E-06	W9	8.60E+01	EPI	1.29E-01	CALC	1.07E+03	EPI	2.26E-04	8.26E+03	1.71E+03		3.36E+02	✔
1,1,2,2-Tetrachloroethane	3.67E-04	EPI	1.50E-02	7.10E-02	W9	7.90E-06	W9	9.49E+01	EPI	1.42E-01	CALC	2.83E+03	EPI	3.36E-05	2.14E+04	4.42E+03		8.98E+02	✔
Tetrachloroethene	1.77E-02	EPI	7.26E-01	7.20E-02	W9	8.20E-06	W9	9.49E+01	EPI	1.42E-01	CALC	2.06E+02	EPI	1.27E-03	3.48E+03	7.19E+02		8.20E+01	✔
Tetryl (Trinitrophenylmethylnitramine)	2.71E-09	EPI	1.11E-07	2.06E-02	W9	5.08E-06	W9	4.61E+03	EPI	6.91E+00	CALC	7.40E+01	EPI	2.85E-08					
Thallium										7.10E+01	SSG								
Toluene	6.64E-03	EPI	2.72E-01	8.70E-02	W9	8.60E-06	W9	2.34E+02	EPI	3.51E-01	CALC	5.26E+02	EPI	4.14E-04	6.10E+03	1.26E+03		2.92E+02	✔
Toxaphene	6.00E-06	EPI	2.46E-04	2.16E-02	W9	5.51E-06	W9	7.72E+04	EPI	1.16E+02	CALC	2.91E-02	EPI	2.33E-09			✔		
Tribromomethane (Bromoform)	5.35E-04	EPI	2.19E-02	1.49E-02	W9	1.03E-05	W9	3.18E+01	EPI	4.77E-02	CALC	3.10E+03	EPI	1.60E-05	3.10E+04	6.41E+03		6.93E+02	✔
1,1,2-Trichloro-1,2,2-trifluoroethane	5.26E-01	EPI	2.16E+01	7.80E-02	W9	8.20E-06	W9	1.97E+02	EPI	2.95E-01	CALC	1.70E+02	EPI	5.60E-03	1.66E+03	3.43E+02		4.95E+02	✔
1,2,4-Trichlorobenzene	1.42E-03	EPI	5.82E-02	3.00E-02	W9	8.23E-06	W9	1.36E+03	EPI	2.03E+00	CALC	4.90E+01	EPI	7.79E-06	4.45E+04	9.18E+03		1.08E+02	✔
1,1,1-Trichloroethane	1.72E-02	EPI	7.05E-01	7.80E-02	W9	8.80E-06	W9	4.39E+01	EPI	6.58E-02	CALC	1.29E+03	EPI	1.67E-03	3.04E+03	6.27E+02		4.12E+02	✔
1,1,2-Trichloroethane	8.24E-04	EPI	3.38E-02	7.80E-02	W9	8.80E-06	W9	6.07E+01	EPI	9.11E-02	CALC	1.10E+03	EPI	9.65E-05	1.26E+04	2.61E+03		2.95E+02	✔

Chemical	H (atm-m^3/mole)	Ref.	H' (unitless)	D_a (cm^2/s)	Ref.	D_w (cm^2/s)	Ref.	K_{oc} (cm^3/g)	Ref.	K_d (cm^3/g)	Ref.	S (mg/L-water)	Ref.	D_A (cm^2/s)	Res/Ind. VF (m^3/kg)	Comm/ VF (m^3/kg)	Solid	Soil SAT (mg/kg)	VOC
Trichloroethylene	9.85E-03	EPI	4.04E-01	7.90E-02	W9	9.10E-06	W9	6.07E+01	EPI	9.11E-02	CALC	1.28E+03	EPI	9.98E-04	3.93E+03	8.12E+02		3.97E+02	✔
Trichlorofluoromethane	9.70E-02	EPI	3.98E+00	8.70E-02	W9	9.70E-06	W9	4.39E+01	EPI	6.58E-02	CALC	1.10E+03	EPI	4.86E-03	1.78E+03	3.68E+02		7.59E+02	✔
2,4,5-Trichlorophenol	1.62E-06	EPI	6.64E-05	2.91E-02	W9	7.03E-06	W9	1.78E+03	EPI	2.67E+00	CALC	1.20E+03	EPI	1.05E-07			✔		
2,4,6-Trichlorophenol	2.60E-06	EPI	1.07E-04	2.61E-02	W9	6.30E-06	W9	1.78E+03	EPI	2.67E+00	CALC	8.00E+02	EPI	9.77E-08			✔		
1,1,2-Trichloropropane	3.17E-04	EPI	1.30E-02	5.78E-02	W9	9.32E-06	W9	9.49E+01	EPI	1.42E-01	CALC	1.90E+03	EPI	2.41E-05	2.53E+04	5.22E+03		6.03E+02	✔
1,2,3-Trichloropropane	3.43E-04	EPI	1.41E-02	7.10E-02	W9	7.90E-06	W9	1.16E+02	EPI	1.74E-01	CALC	1.75E+03	EPI	2.87E-05	2.32E+04	4.79E+03		6.10E+02	✔
Triethylamine	1.49E-04	EPI	6.11E-03	8.81E-02	W9	7.88E-06	W9	5.08E+01	EPI	7.62E-02	CALC	6.86E+04	EPI	2.21E-05	2.64E+04	5.45E+03		1.72E+04	✔
2,4,6-Trinitrotoluene	2.08E-08	EPI	8.53E-07	2.94E-02	W9	7.90E-06	W9	2.81E+03	EPI	4.22E+00	CALC	1.15E+02	EPI	7.15E-08					
Uranium (soluable salts)										4.50E+02	Baes								
Vanadium										1.00E+03	SSG								
Vinyl acetate	5.11E-04	EPI	2.10E-02	8.50E-02	W9	9.20E-06	W9	5.58E+00	EPI	8.37E-03	CALC	2.00E+04	EPI	9.57E-05	1.27E+04	2.62E+03		3.68E+03	✔
Vinyl bromide	1.23E-02	EPI	5.04E-01	8.69E-02	W9	1.17E-05	W9	2.17E+01	EPI	3.26E-02	CALC	5.08E+03	EPI	1.62E-03	3.09E+03	6.38E+02		1.34E+03	✔
Vinyl chloride	2.78E-02	EPI	1.14E+00	1.06E-01	W9	1.23E-05	W9	2.17E+01	EPI	3.26E-02	CALC	8.80E+03	EPI	3.50E-03	2.10E+03	4.34E+02		2.95E+03	✔
m-Xylene	7.18E-03	EPI	2.94E-01	7.00E-02	W9	7.80E-06	W9	3.75E+02	EPI	5.63E-01	CALC	1.61E+02	EPI	2.60E-04	7.70E+03	1.59E+03		1.24E+02	✔
o-Xylene	5.18E-03	EPI	2.12E-01	8.70E-02	W9	1.00E-05	W9	3.83E+02	EPI	5.74E-01	CALC	1.06E+02	EPI	2.33E-04	8.14E+03	1.68E+03		8.18E+01	✔
p-Xylene	6.90E-03	EPI	2.83E-01	6.80E-02	W9	8.40E-06	W9	3.80E+02	EPI	5.70E-01	CALC	1.60E+02	EPI	2.41E-04	8.00E+03	1.65E+03		1.24E+02	✔
Xylenes	5.18E-03	EPI	2.12E-01	7.37E-02	W9	9.34E-06	W9	3.83E+02	EPI	5.74E-01	CALC	1.06E+02	EPI	1.97E-04	8.84E+03	1.83E+03		8.18E+01	✔
Zinc										6.20E+01	SSG								
Petroleum Hydrocarbons																			
Aliphatics: C5 to C8	1.30E+00	18b	5.40E+01					2265											
C9 to C12	1.56E+00	18b	6.50E+01					150000											
C9 to C18	1.66E+00	18b	6.90E+01					680000											
C19 to C36																			
Aromatics: C9 to C10	7.92E-03	18b	3.30E-01					1778											
C11 to C22	7.20E-04	18b	3.00E-02					5012											

Notes:
MW – Molecular weight
H' – Dimensionless Henry's Law Constant
D_w – Diffusivity in water
K_d – Soil-water partition coefficient
D_A – Apparent diffusivity (calculated for VOCs only)
SAT – Soil saturation limit (calculated for VOCs not solid at soil temperature only)
H – Henry's Law Constant
D_a – Diffusivity in air
K_{oc} – Soil organic carbon partition coefficient
S - Solubility in water
VF – Volatilization factor (calculated for VOCs only)
VOC – Volatile organic compound

EPI= US EPA. 2012. Estimation Programs Interface (EPI) Suite™ for Microsoft® Windows, v 4.11. Washington, DC, USA.
W9= US EPA. 2006. Water9, Version 3.0. Wastewater Treatment Model
CALC =Calculated;
SSG=US EPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Office of Emergency and Remedial Response, Washington, D.C. OSWER 9355.4-24. December. http://www.epa.gov/superfund/health/conmedia/soil/pdfs/ssg_main.pdf
Baes= Baes, C.F. 1984. Oak Ridge National Laboratory. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture

a -Hnery's Law Constants obtained from 1) EPI Suite Version 4.11 (a. experimental value; b. bond method, then c. group method) 2) US EPA Soil Screening Guidance (2002).

d -H' values = H*41 (US EPA Soil Screening Guidance, 2002)

c- Da and Dw values obtained from 1) US EPA (2006) Water 9 Wastewater Treatment Model; 2) US EPA Soil Screening Guidance (2002)

d- Koc values obtained from US EPA EPI Suite, Version 4.11 (a. MCI method; b. Kow method)

b -foc = 1.5E-03: Soil Survey Laboratory Database for New Mexico, National Resources Conservation Service, U.S. Dept of Agriculture
e- Kd for organics = Koc * foc. Kds for inorganics obtained from 1) US EPA Soil Screening Guidance (2002); 2) Baes, C.F. 1984. Oak Ridge National Laboratory. *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture*.

The Kd value for elemental mercury is based on the Kd for mercury 2+

The Kd value for methyl mercury Is based on the Kd for mercury 2+

The Kd value for mercury salts is based on the Kd for mercury 2+

The Kd values for nitrate and nitrite are based on the Kd for nitrogen

The Kd value for perchlorate is based on the Kd for chlorine

Table B-3: Physical and Chemical Constants for the Dermal Tap-Water Pathway

Chemical	CAS. NO.	MW (g/mole)	Ref.	Kp (cm/hr)	Ref.	FA (unitless)	Ref.	τ_{event} (hr/event)	B (unitless)	b	c	t* (hr)	DA_event carc	DA_event noncarc	DA_event mutagen
Acenaphthene	83-32-9	154.21	EPI	8.60E-02	EPI	1	E	7.67E-01	4.11E-01	6.20E-01	6.47E-01	1.84E+00		1.47E-01	
Acetaldehyde	75-07-0	44.05	EPI	5.27E-04	EPI	1	E	1.85E-01	1.35E-03	3.04E-01	3.34E-01	4.45E-01			
Acetone	67-64-1	58.08	EPI	5.12E-04	EPI	1	E	2.22E-01	1.50E-03	3.04E-01	3.34E-01	5.33E-01		2.13E+00	
Acetophenone	98-86-2	120.15	EPI	3.72E-03	EPI	1	E	4.94E-01	1.57E-02	3.13E-01	3.44E-01	1.19E+00		2.37E-01	
Acrylonitrile	107-02-8	56.06	EPI	1.16E-03	EPI	1	E	2.16E-01	3.34E-03	3.05E-01	3.36E-01	5.19E-01	1.81E-04	9.48E-02	
Acrolein	107-13-1	53.06	EPI	7.48E-04	EPI	1	E	2.08E-01	2.10E-03	3.05E-01	3.35E-01	5.00E-01		1.19E-03	
Alachlor	15972-60-8	270	EPI	1.10E-02	EPI	0.9	E	3.40E+00	6.95E-02	3.47E-01	3.81E-01	8.16E+00	5.71E-06	9.48E-02	
Aldrin	309-00-2	364.92	EPI	2.93E-01	EPI	1	E	1.16E+01	2.15E+00	4.07E+00	2.26E+00	4.77E+01	5.71E-06	7.11E-05	
Aluminum	7429-90-5	26.98	P	1.00E-03	E	1	E	1.49E-01	2.00E-03	3.04E-01	3.35E-01	3.57E-01		2.37E+00	
Anthracene	120-12-7	178.24	EPI	1.42E-01	EPI	1	E	1.05E+00	7.29E-01	9.82E-01	9.22E-01	4.04E+00		7.11E-01	
Antimony	7440-36-0	121.76	P	1.00E-03	E	1	E	5.05E-01	4.24E-03	3.06E-01	3.36E-01	1.21E+00		1.42E-04	
Arsenic	7440-38-2	74.92	P	1.00E-03	E	1	E	2.76E-01	3.33E-03	3.05E-01	3.36E-01	6.62E-01	6.52E-05	7.11E-04	
Atrazine	1912-24-9	220	P												
Barium	7440-39-3	137.33	P	1.00E-03	E	1	E	6.17E-01	4.51E-03	3.06E-01	3.36E-01	1.48E+00		3.32E-02	
Benzene	71-43-2	78.11	EPI	1.49E-02	EPI	1	E	2.87E-01	5.06E-02	3.35E-01	3.68E-01	6.90E-01	1.78E-03	9.48E-03	
Benzidine	92-87-5	184.24	EPI	1.13E-03	EPI	1	E	1.13E+00	5.90E-03	3.07E-01	3.37E-01	2.71E+00		7.11E-03	1.36E-07
Benzo(a)anthracene	56-55-3	228.3	EPI	5.52E-01	EPI	1	E	1.99E+00	3.21E+00	7.99E+00	3.29E+00	8.47E+00			4.27E-05
Benzo(a)pyrene	50-32-8	252.32	EPI	7.13E-01	EPI	1	E	2.72E+00	4.36E+00	1.38E+01	4.42E+00	1.18E+01			4.27E-06
Benzo(b)fluoranthene	205-99-2	252.32	EPI	4.17E-01	EPI	1	E	2.72E+00	2.55E+00	5.37E+00	2.64E+00	1.13E+01			4.27E-05
Benzo(k)fluoranthene	207-08-9	252.32	EPI	6.91E-01	EPI	1	E	2.72E+00	4.22E+00	1.31E+01	4.29E+00	1.18E+01			4.27E-04
Beryllium	7440-41-7	9.01	P	1.00E-03	E	1	E	1.18E-01	1.15E-03	3.04E-01	3.34E-01	2.83E-01		3.32E-05	
a-BHC (HCH)	319-84-6	290.83	EPI	2.06E-02	EPI	1	E	4.47E+00	1.35E-01	3.92E-01	4.29E-01	1.07E+01	1.55E-05	1.90E-02	
b-BHC (HCH)	319-85-7	290.83	EPI	2.06E-02	EPI	1	E	4.47E+00	1.35E-01	3.92E-01	4.29E-01	1.07E+01	5.44E-05		
g-BHC	58-89-9	290.83	EPI	2.06E-02	EPI	0.9	E	4.47E+00	1.35E-01	3.92E-01	4.29E-01	1.07E+01	8.90E-05	7.11E-04	
1,1-Biphenyl	92-52-4	154.21	EPI	9.87E-02	EPI	1	E	7.67E-01	4.71E-01	6.80E-01	6.98E-01	1.84E+00	1.19E-02	1.19E+00	
Bis(2-chloroethyl) ether	111-44-4	143.01	EPI	1.78E-03	EPI	1	E	6.64E-01	8.19E-03	3.08E-01	3.39E-01	1.59E+00	8.90E-05		
Bis(2-chloroisopropyl) ether	108-60-1	171.07	EPI	7.64E-03	EPI	1	E	9.53E-01	3.84E-02	3.27E-01	3.59E-01	2.29E+00	1.40E-03		
Bis(2-ethylhexyl) phthalate	117-81-7	390.57	EPI	1.13E+00	EPI	0.8	E	1.62E+01	8.59E+00	4.99E+01	8.62E+00	7.28E+01	6.99E-03	4.74E-02	
Bis(chloromethyl) ether	542-88-1	114.96	EPI	8.55E-04	EPI	1	E	4.62E-01	3.53E-03	3.05E-01	3.36E-01	1.11E+00	4.45E-07		
Boron	7440-42-8	10.81	P	1.00E-03	E	1	E	1.21E-01	1.26E-03	3.04E-01	3.34E-01	2.90E-01		4.74E-01	
Bromodichloromethane	75-27-4	163.83	EPI	4.02E-03	EPI	1	E	8.68E-01	1.98E-02	3.15E-01	3.47E-01	2.08E+00	1.58E-03	4.74E-02	
Bromomethane	74-83-9	94.94	EPI	2.84E-03	EPI	1	E	3.57E-01	1.06E-02	3.10E-01	3.40E-01	8.57E-01		3.32E-03	

Chemical	CAS. NO.	MW (g/mole)	Ref.	Kp (cm/hr)	Ref.	FA (unitless)	Ref.	τ_{event} (hr/event)	B (unitless)	b	c	t* (hr)	DA_event carc	DA_event noncarc	DA_event mutagen
1,3-Butadiene	106-99-0	54.09	EPI	1.64E-02	EPI	1	E	2.11E-01	4.64E-02	3.32E-01	3.65E-01	5.06E-01	2.88E-05		
2-Butanone (Methyl ethyl ketone, MEK)	78-93-3	72.11	EPI	9.62E-04	EPI	1	E	2.66E-01	3.14E-03	3.05E-01	3.35E-01	6.39E-01		1.42E+00	
tert-Butyl methyl ether (MTBE)	1634-04-4	88.15	EPI	2.11E-03	EPI	1	E	3.27E-01	7.62E-03	3.08E-01	3.38E-01	7.85E-01	5.44E-02		
Cadmium	7440-43-9	112.41	P	1.00E-03	E	1	E	4.47E-01	4.08E-03	3.06E-01	3.36E-01	1.07E+00		3.07E-05	
Calcium	0	0	0												
Carbofuran	1563-66-2	220	EPI	3.10E-03	EPI	1	E	1.80E+00	1.80E-02	3.14E-01	3.45E-01	4.32E+00		1.19E-02	
Carbon disulfide	75-15-0	76.13	EPI	1.14E-02	EPI	1	E	2.80E-01	3.83E-02	3.27E-01	3.59E-01	6.73E-01		2.37E-01	
Carbon tetrachloride	56-23-5	153.82	EPI	1.63E-02	EPI	1	E	7.63E-01	7.78E-02	3.52E-01	3.87E-01	1.83E+00	1.40E-03	9.48E-03	
Chlordane	12789-03-6	409.78	EPI	1.07E-01	EPI	0.7	E	2.07E+01	8.33E-01	1.12E+00	1.01E+00	7.96E+01	2.80E-04	1.19E-03	
2-Chloroacetophenone	532-27-4	154.6	EPI	4.06E-03	EPI	1	E	7.71E-01	1.94E-02	3.15E-01	3.46E-01	1.85E+00			
2-Chloro-1,3-butadiene	126-99-8	88.54	EPI	2.38E-02	EPI	1	E	3.29E-01	8.61E-02	3.58E-01	3.93E-01	7.89E-01		4.74E-02	
1-Chloro-1,1-difluoroethane	75-68-3	100.5	EPI	9.89E-03	EPI	1	E	3.84E-01	3.81E-02	3.27E-01	3.59E-01	9.21E-01			
Chlorobenzene	108-90-7	112.56	EPI	2.82E-02	EPI	1	E	4.48E-01	1.15E-01	3.78E-01	4.14E-01	1.08E+00		4.74E-02	
1-Chlorobutane	109-69-3	92.57	EPI	2.69E-02	EPI	1	E	3.46E-01	9.95E-02	3.67E-01	4.03E-01	8.31E-01		9.48E-02	
Chlorodifluoromethane	75-45-6	86.47	EPI	2.68E-03	EPI	1	E	3.20E-01	9.59E-03	3.09E-01	3.40E-01	7.68E-01			
Chloroform	67-66-3	119.38	EPI	6.83E-03	EPI	1	E	4.89E-01	2.87E-02	3.21E-01	3.53E-01	1.17E+00	5.15E-03	2.37E-02	
Chloromethane	74-87-3	50.49	EPI	3.28E-03	EPI	1	E	2.01E-01	8.96E-03	3.09E-01	3.39E-01	4.83E-01	7.53E-03		
b-Chloronaphthalene	91-58-7	162.62	EPI	7.49E-02	EPI	1	E	8.55E-01	3.67E-01	5.79E-01	6.11E-01	2.05E+00		1.90E-01	
o-Chloronitrobenzene	88-73-3	157.56	EPI	6.30E-03	EPI	1	E	8.01E-01	3.04E-02	3.22E-01	3.54E-01	1.92E+00	3.26E-04	7.11E-03	
p-Chloronitrobenzene	100-00-5	157.56	EPI	7.93E-03	EPI	1	E	8.01E-01	3.83E-02	3.27E-01	3.59E-01	1.92E+00	1.55E-02	2.37E-03	
2-Chlorophenol	95-57-8	128.56	EPI	7.99E-03	EPI	1	E	5.51E-01	3.48E-02	3.25E-01	3.57E-01	1.32E+00		1.19E-02	
2-Chloropropane	75-29-6	78.54	EPI	1.04E-02	EPI	1	E	2.89E-01	3.54E-02	3.25E-01	3.57E-01	6.94E-01			
o-Chlorotoluene	95-49-8	126.59	EPI	5.72E-02	EPI	1	E	5.37E-01	2.48E-01	4.76E-01	5.15E-01	1.29E+00		4.74E-02	
Chromium III	16065-83-1	52	P	1.00E-03	E	1	E	2.05E-01	2.77E-03	3.05E-01	3.35E-01	4.93E-01		4.62E-02	
Chromium VI	18540-29-9	52	P	2.00E-03	E	1	E	2.05E-01	5.55E-03	3.07E-01	3.37E-01	4.93E-01		1.78E-04	1.56E-06
Chromium (Total)	0	52	P	1.00E-03	E	1	E	2.05E-01	2.77E-03	3.05E-01	3.35E-01	4.93E-01	1.78E-05	3.96E-02	
Chrysene	218-01-9	228.3	EPI	5.96E-01	EPI	1	E	1.99E+00	3.46E+00	9.15E+00	3.54E+00	8.52E+00			4.27E-03
Cobalt	7440-48-4	58.93	EPI	4.00E-04	EPI	1	E	2.20E-01	1.18E-03	3.04E-01	3.34E-01	5.40E-01		7.11E-04	
Copper	7440-50-8	63.55	P	1.00E-03	E	1	E	2.38E-01	3.07E-03	3.05E-01	3.35E-01	5.72E-01		9.48E-02	
Crotonaldehyde	123-73-9	70.09	EPI	1.59E-03	EPI	1	E	2.59E-01	5.12E-03	3.06E-01	3.37E-01	6.22E-01	5.15E-05	2.37E-03	
Cumene (isopropylbenzene)	98-82-8	120.2	EPI	8.97E-02	EPI	1	E	4.95E-01	3.78E-01	5.89E-01	6.20E-01	1.19E+00		2.37E-01	
Cyanide	57-12-5	27.03	EPI	7.54E-04	EPI	1	E	1.49E-01	1.51E-03	3.04E-01	3.34E-01	3.57E-01		1.42E-03	
Cyanogen	460-19-5	52.04	EPI	8.90E-04	EPI	1	E	2.05E-01	2.47E-03	3.05E-01	3.35E-01	4.93E-01		2.37E-03	

Chemical	CAS. NO.	MW (g/mole)	Ref.	Kp (cm/hr)	Ref.	FA (unitless)	Ref.	τ_{event} (hr/event)	B (unitless)	b	c	t* (hr)	DA_event carc	DA_event noncarc	DA_event mutagen
Cyanogen bromide	506-68-3	105.92	EPI	2.55E-04	EPI	1	E	4.11E-01	1.01E-03	3.04E-01	3.34E-01	9.88E-01		2.13E-01	
Cyanogen chloride	506-77-4	61.47	EPI	3.94E-04	EPI	1	E	2.32E-01	1.19E-03	3.04E-01	3.34E-01	5.57E-01		1.19E-01	
DDD	72-54-8	320.05	EPI	2.51E-01	EPI	0.8	E	6.51E+00	1.73E+00	2.89E+00	1.85E+00	2.62E+01	4.08E-04		
DDE	72-55-9	318.03	EPI	5.45E-01	EPI	0.8	E	6.34E+00	3.74E+00	1.05E+01	3.81E+00	2.73E+01	2.88E-04		
DDT	50-29-3	354.49	EPI	6.28E-01	EPI	0.7	E	1.01E+01	4.55E+00	1.50E+01	4.61E+00	4.42E+01	2.88E-04	1.19E-03	
Dibenz(a,h)anthracene	53-70-3	278.36	EPI	9.53E-01	EPI	0.6	E	3.80E+00	6.12E+00	2.61E+01	6.16E+00	1.69E+01			4.27E-06
1,2-Dibromo-3-chloropropane	96-12-8	236.33	EPI	6.85E-03	EPI	1	E	2.21E+00	4.05E-02	3.28E-01	3.61E-01	5.31E+00		4.74E-04	3.90E-05
Dibromochloromethane	124-48-1	208.28	EPI	2.89E-03	EPI	1	E	1.54E+00	1.60E-02	3.13E-01	3.44E-01	3.70E+00	1.17E-03	4.74E-02	
1,2-Dibromoethane	106-93-4	187.86	EPI	2.78E-03	EPI	1	E	1.18E+00	1.47E-02	3.12E-01	3.43E-01	2.84E+00	4.89E-05	2.13E-02	
1,4-Dichloro-2-butene	764-41-0	125	EPI	1.66E-02	EPI	1	E	5.26E-01	7.14E-02	3.48E-01	3.83E-01	1.26E+00			
1,2-Dichlorobenzene	95-50-1	147	EPI	4.46E-02	EPI	1	E	6.99E-01	2.08E-01	4.45E-01	4.84E-01	1.68E+00		2.13E-01	
1,4-Dichlorobenzene	106-46-7	147	EPI	4.53E-02	EPI	1	E	6.99E-01	2.11E-01	4.48E-01	4.86E-01	1.68E+00	1.81E-02	1.66E-01	
3,3-Dichlorobenzidine	91-94-1	253.13	EPI	1.28E-02	EPI	1	E	2.75E+00	7.83E-02	3.53E-01	3.87E-01	6.59E+00	2.17E-04		
Dichlorodifluoromethane	75-71-8	120.91	EPI	8.95E-03	EPI	1	E	4.99E-01	3.79E-02	3.27E-01	3.59E-01	1.20E+00		4.74E-01	
1,1-Dichloroethane	75-34-3	98.96	EPI	6.75E-03	EPI	1	E	3.76E-01	2.58E-02	3.19E-01	3.51E-01	9.03E-01	1.72E-02	4.74E-01	
1,2-Dichloroethane	107-06-2	98.96	EPI	4.20E-03	EPI	1	E	3.76E-01	1.61E-02	3.13E-01	3.44E-01	9.03E-01	1.08E-03	1.42E-02	
cis-1,2-Dichloroethene	156-59-2	96.94	EPI	9.55E-03	EPI	1	E	3.66E-01	3.62E-02	3.26E-01	3.58E-01	8.80E-01		4.74E-03	
trans-1,2-Dichloroethene	156-60-5	96.94	EPI	9.55E-03	EPI	1	E	3.66E-01	3.62E-02	3.26E-01	3.58E-01	8.80E-01		4.74E-02	
1,1-Dichloroethene	75-35-4	96.94	EPI	1.17E-02	EPI	1	E	3.66E-01	4.43E-02	3.31E-01	3.63E-01	8.80E-01		1.19E-01	
2,4-Dichlorophenol	120-83-2	163	EPI	2.06E-02	EPI	1	E	8.59E-01	1.01E-01	3.68E-01	4.04E-01	2.06E+00		7.11E-03	
1,2-Dichloropropane	78-87-5	112.99	EPI	7.53E-03	EPI	1	E	4.51E-01	3.08E-02	3.22E-01	3.54E-01	1.08E+00	2.72E-03	2.13E-01	
1,3-Dichloropropene	542-75-6	110.97	EPI	8.34E-03	EPI	1	E	4.39E-01	3.38E-02	3.24E-01	3.56E-01	1.05E+00	9.79E-04	7.11E-02	
Dicyclopentadiene	77-73-6	132.21	EPI	3.60E-02	EPI	1	E	5.78E-01	1.59E-01	4.09E-01	4.47E-01	1.39E+00		1.90E-01	
Dieldrin	60-57-1	380.91	EPI	3.26E-02	EPI	0.8	E	1.43E+01	2.45E-01	4.74E-01	5.13E-01	3.42E+01	6.12E-06	1.19E-04	
Diethyl phthalate	84-66-2	222.24	EPI	3.60E-03	EPI	1	E	1.84E+00	2.06E-02	3.16E-01	3.47E-01	4.43E+00		1.90E+00	
Di-n-butyl phthalate (Dibutyl phthalate)	84-74-2	278.35	EPI	4.20E-02	EPI	0.9	E	3.80E+00	2.70E-01	4.94E-01	5.32E-01	9.12E+00		2.37E-01	
2,4-Dimethylphenol	105-67-9	122.17	EPI	1.09E-02	EPI	1	E	5.07E-01	4.63E-02	3.32E-01	3.65E-01	1.22E+00		4.74E-02	
4,6-Dinitro-o-cresol	100-21-0	170	EPI	3.15E-03	EPI	1	E	9.40E-01	1.58E-02	3.13E-01	3.44E-01	2.26E+00		1.90E-04	
2,4-Dinitrophenol	534-52-1	198.14	EPI	1.87E-03	EPI	1	E	1.35E+00	1.01E-02	3.09E-01	3.40E-01	3.24E+00		4.74E-03	
Dimethyl phthalate	51-28-5	184.11	EPI	3.90E-03	EPI	1	E	9.00E-01	2.04E-02	3.16E-01	3.47E-01	2.10E+00		4.74E-03	
2,4-Dinitrotoluene	121-14-2	182.14	EPI	3.08E-03	EPI	1	E	1.10E+00	1.60E-02	3.13E-01	3.44E-01	2.64E+00	3.16E-04	4.74E-03	
2,6-Dintitrotoluene	606-20-2	182.14	EPI	3.70E-03	EPI	1	E	1.10E+00	1.92E-02	3.15E-01	3.46E-01	2.64E+00	6.52E-05	7.11E-04	
2,4/2,6-Dintrotoluene Mixture	25321-14-6	182.14	EPI	4.16E-03	EPI	1	E	1.10E+00	2.16E-02	3.17E-01	3.48E-01	2.64E+00	1.44E-04		

Chemical	CAS. NO.	MW (g/mole)	Ref.	Kp (cm/hr)	Ref.	FA (unitless)	Ref.	τ_{event} (hr/event)	B (unitless)	b	c	t* (hr)	DA_event carc	DA_event noncarc	DA_event mutagen
1,4-Dioxane	123-91-1	88.11	EPI	3.32E-04	EPI	1	E	3.27E-01	1.20E-03	3.04E-01	3.34E-01	7.85E-01	9.79E-04	7.11E-02	
1,2-Diphenylhydrazine	122-66-7	184.24	EPI	1.30E-02	EPI	1	E	1.13E+00	6.79E-02	3.46E-01	3.80E-01	2.71E+00	1.22E-04		
Endosulfan	115-29-7	406.92	EPI	2.86E-03	EPI	1	E	1.99E+01	2.22E-02	3.17E-01	3.48E-01	4.79E+01		1.42E-02	
Endrin	72-20-8	380.91	EPI	3.26E-02	EPI	0.8	E	1.43E+01	2.45E-01	4.74E-01	5.13E-01	3.42E+01		7.11E-04	
Epichlorohydrin	106-89-8	92.53	EPI	9.44E-04	EPI	1	E	3.46E-01	3.49E-03	3.05E-01	3.36E-01	8.31E-01	9.89E-03	1.42E-02	
Ethyl acetate	141-78-6	88.11	EPI	1.53E-03	EPI	1	E	3.27E-01	5.52E-03	3.07E-01	3.37E-01	7.85E-01		2.13E+00	
Ethyl acrylate	140-88-5	100.12	EPI	3.24E-03	EPI	1	E	3.82E-01	1.25E-02	3.11E-01	3.42E-01	9.16E-01	2.04E-03		
Ethyl chloride	75-00-3	64.52	EPI	6.07E-03	EPI	1	E	2.41E-01	1.88E-02	3.15E-01	3.46E-01	5.79E-01			
Ethyl ether	60-29-7	74.12	EPI	2.35E-03	EPI	1	E	2.73E-01	7.78E-03	3.08E-01	3.39E-01	6.55E-01		4.74E-01	
Ethyl methacrylate	97-63-2	114.15	EPI	6.98E-03	EPI	1	E	4.58E-01	2.87E-02	3.21E-01	3.53E-01	1.10E+00		2.13E-01	
Ethylbenzene	100-41-4	106.17	EPI	4.93E-02	EPI	1	E	4.13E-01	1.95E-01	4.35E-01	4.74E-01	9.91E-01	8.90E-03	2.37E-01	
Ethylene oxide	75-21-8	44.05	EPI	5.60E-04	EPI	1	E	1.85E-01	1.43E-03	3.04E-01	3.34E-01	4.45E-01	3.16E-04		
Fluoranthene	206-44-0	202.26	EPI	3.08E-01	EPI	1	E	1.43E+00	1.68E+00	2.78E+00	1.81E+00	5.72E+00		9.48E-02	
Fluorene	86-73-7	166.22	EPI	1.10E-01	EPI	1	E	8.95E-01	5.45E-01	7.59E-01	7.61E-01	2.15E+00		9.48E-02	
Fluoride	7782-41-4	19	P	1.00E-03	E	1	E	1.34E-01	1.68E-03	3.04E-01	3.34E-01	3.22E-01		1.42E-01	
Furan	110-00-9	68.08	EPI	5.05E-03	EPI	1	E	2.53E-01	1.60E-02	3.13E-01	3.44E-01	6.06E-01		2.37E-03	
Glyphosate	1071-83-6	170	EPI	4.50E-08	EPI	1	E	9.30E-01	2.26E-07	3.03E-01	3.33E-01	2.20E+00		2.37E-01	
Heptachlor	76-44-8	373.32	EPI	5.44E-02	EPI	0.8	E	1.29E+01	4.04E-01	6.14E-01	6.42E-01	3.10E+01	2.17E-05	1.19E-03	
Hexachlorobenzene	118-74-1	284.78	EPI	2.54E-01	EPI	0.9	E	4.13E+00	1.65E+00	2.69E+00	1.77E+00	1.65E+01	6.12E-05	1.90E-03	
Hexachloro-1,3-butadiene	87-68-3	260.76	EPI	8.10E-02	EPI	0.9	E	3.03E+00	5.03E-01	7.13E-01	7.25E-01	7.27E+00	1.25E-03	2.37E-03	
Hexachlorocyclopentadiene	77-47-4	272.77	EPI	1.03E-01	EPI	1	E	3.54E+00	6.54E-01	8.86E-01	8.56E-01	1.39E+01		1.42E-02	
Hexachloroethane	67-72-1	236.74	EPI	4.15E-02	EPI	1	E	2.22E+00	2.46E-01	4.75E-01	5.13E-01	5.34E+00	2.45E-03	1.66E-03	
n-Hexane	110-54-3	86.18	EPI	2.01E-01	EPI	1	E	3.19E-01	7.18E-01	9.67E-01	9.12E-01	1.24E+00		1.42E-01	
HMX	2691-41-0	296.16	EPI	4.36E-05	EPI	1	E	4.78E+00	2.89E-04	3.03E-01	3.34E-01	1.15E+01		1.19E-01	
Hydrazine anhydride	302-01-2	32.05	EPI	4.36E-05	EPI	1	E	1.59E-01	9.49E-05	3.03E-01	3.33E-01	3.81E-01	3.26E-05		
Hydrogen cyanide	74-90-8	27.03	EPI	7.54E-04	EPI	1	E	1.49E-01	1.51E-03	3.04E-01	3.34E-01	3.57E-01		1.42E-03	
Indeno(1,2,3-c,d)pyrene	193-39-5	276.34	EPI	1.24E+00	EPI	0.6	E	3.70E+00	7.93E+00	4.28E+01	7.97E+00	1.66E+01			4.27E-05
Iron	7439-89-6	55.85	P	1.00E-03	E	1	E	2.16E-01	2.87E-03	3.05E-01	3.35E-01	5.18E-01		1.66E+00	
Isobutanol (Isobutyl alcohol)	78-83-1	74.12	EPI	1.92E-03	EPI	1	E	2.73E-01	6.36E-03	3.07E-01	3.38E-01	6.55E-01		7.11E-01	
Isophorone	78-59-1	138.21	EPI	3.54E-03	EPI	1	E	6.24E-01	1.60E-02	3.13E-01	3.44E-01	1.50E+00	1.03E-01	4.74E-01	
Lead	7439-92-1	207.2	P	1.00E-03	E	1	E	1.52E+00	5.54E-03	3.07E-01	3.37E-01	3.65E+00			
Lead (tetraethyl-)	78-00-2	323.45	EPI	1.37E-02	EPI	1	E	6.80E+00	9.48E-02	3.64E-01	3.99E-01	1.63E+01		2.37E-07	
Maleic hydrazide	123-33-1	112.09	EPI	1.02E-04	EPI	1	E	4.46E-01	4.15E-04	3.04E-01	3.34E-01	1.07E+00		1.19E+00	

Chemical	CAS. NO.	MW (g/mole)	Ref.	Kp (cm/hr)	Ref.	FA (unitless)	Ref.	τ_{event} (hr/event)	B (unitless)	b	c	t* (hr)	DA_event carc	DA_event noncarc	DA_event mutagen
Manganese	7439-96-5	54.94	P	1.00E-03	E	1	E	2.13E-01	2.85E-03	3.05E-01	3.35E-01	5.12E-01		1.33E-02	
Mercury (elemental)	7439-97-6	200.59	EPI	1.00E-03	E	1	E	1.39E+00	5.45E-03	3.07E-01	3.37E-01	3.35E+00			
Mercury (methyl)	22967-92-6	215.63	EPI	1.00E-03	E	1	E	1.69E+00	5.65E-03	3.07E-01	3.37E-01	4.06E+00		2.37E-04	
Mercury Chloride (Mercury Salts)	7487-94-7	271.5	EPI	1.00E-03	E	1	E	3.48E+00	6.34E-03	3.07E-01	3.38E-01	8.35E+00		4.98E-05	
Methacrylonitrile	126-98-7	67.09	EPI	1.86E-03	EPI	1	E	2.49E-01	5.86E-03	3.07E-01	3.37E-01	5.99E-01		2.37E-04	
Methomyl	16752-77-5	162.21	EPI	4.82E-04	EPI	1	E	8.50E-01	2.36E-03	3.05E-01	3.35E-01	2.04E+00		5.93E-02	
Methyl acetate	79-20-9	74.08	EPI	7.92E-04	EPI	1	E	2.73E-01	2.62E-03	3.05E-01	3.35E-01	6.55E-01		2.37E+00	
Methyl acrylate	96-33-3	86.09	EPI	1.75E-03	EPI	1	E	3.19E-01	6.25E-03	3.07E-01	3.38E-01	7.65E-01		7.11E-02	
Methyl isobutyl ketone	108-10-1	100.16	EPI	3.19E-03	EPI	1	E	3.82E-01	1.23E-02	3.11E-01	3.42E-01	9.17E-01		1.90E-01	
Methyl methacrylate	80-62-6	100.12	EPI	3.55E-03	EPI	1	E	3.82E-01	1.37E-02	3.12E-01	3.43E-01	9.16E-01		3.32E+00	
Methyl styrene (alpha)	98-83-9	118.18	EPI	6.99E-02	EPI	1	E	4.82E-01	2.92E-01	5.13E-01	5.50E-01	1.16E+00		1.66E-01	
Methyl styrene (mixture)	25013-15-4	118.18	EPI	6.60E-02	EPI	1	E	4.82E-01	2.76E-01	4.99E-01	5.37E-01	1.16E+00		1.42E-02	
Methylcyclohexane	108-87-2	98.19	EPI	1.10E-01	EPI	1	E	3.72E-01	4.19E-01	6.28E-01	6.54E-01	8.94E-01			
Methylene bromide (Dibromomethane)	74-95-3	173.84	EPI	2.23E-03	EPI	1	E	9.88E-01	1.13E-02	3.10E-01	3.41E-01	2.37E+00		2.37E-02	
Methylene chloride	75-09-2	84.93	EPI	3.54E-03	EPI	1	E	3.14E-01	1.25E-02	3.11E-01	3.42E-01	7.53E-01		1.42E-02	1.56E-02
1-Methylnaphthalene	90-12-0	140	EPI	9.30E-02	EPI	1	E	6.60E-01	4.23E-01	6.32E-01	6.57E-01	1.60E+00	3.37E-03	1.66E-01	
2-Methylnaphthalene	91-57-6	140	EPI	9.20E-02	EPI	1	E	6.60E-01	4.19E-01	6.28E-01	6.54E-01	1.60E+00		9.48E-03	
Molybdenum	7439-98-7	95.96	P	1.00E-03	E	1	E	3.62E-01	3.77E-03	3.06E-01	3.36E-01	8.69E-01		1.19E-02	
Naphthalene	91-20-3	128.18	EPI	4.66E-02	EPI	1	E	5.48E-01	2.03E-01	4.41E-01	4.80E-01	1.32E+00		4.74E-02	
Nickel	7440-02-0	58.69	EPI	2.00E-04	E	1	E	2.24E-01	5.89E-04	3.04E-01	3.34E-01	5.37E-01		1.90E-03	
Nitrate	14797-55-8	62	EPI	1.00E-03	E	1	E	2.34E-01	3.03E-03	3.05E-01	3.35E-01	5.61E-01		3.79E+00	
Nitrite	14797-65-0	47.01	EPI	1.00E-03	E	1	E	1.93E-01	2.64E-03	3.05E-01	3.35E-01	4.62E-01		2.37E-01	
Nitrobenzene	98-95-3	123.11	EPI	5.41E-03	EPI	1	E	5.14E-01	2.31E-02	3.17E-01	3.49E-01	1.23E+00		4.74E-03	
Nitroglycerin	55-63-0	227.09	EPI	9.94E-04	EPI	1	E	1.96E+00	5.76E-03	3.07E-01	3.37E-01	4.71E+00	5.76E-03	2.37E-04	
Nitrophenol	0	0	0												
N-Nitrosodiethylamine	55-18-5	102.14	EPI	8.72E-04	EPI	1	E	3.92E-01	3.39E-03	3.05E-01	3.36E-01	9.41E-01			2.08E-07
N-Nitrosodimethylamine	62-75-9	74.08	EPI	2.51E-04	EPI	1	E	2.73E-01	8.31E-04	3.04E-01	3.34E-01	6.55E-01		1.90E-05	6.12E-07
N-Nitrosodi-*n*-butylamine	924-16-3	158.25	EPI	1.13E-02	EPI	1	E	8.08E-01	5.47E-02	3.37E-01	3.71E-01	1.94E+00	1.81E-05		
N-Nitrosodiphenylamine	86-30-6	198.23	EPI	1.45E-02	EPI	1	E	1.35E+00	7.85E-02	3.53E-01	3.88E-01	3.25E+00	2.00E-02		
N-Nitrosopyrrolidine	930-55-2	100.12	EPI	3.21E-04	EPI	1	E	3.82E-01	1.24E-03	3.04E-01	3.34E-01	9.16E-01	4.66E-05		
m-Nitrotoluene	99-08-1	137.14	EPI	1.13E-02	EPI	1	E	6.15E-01	5.09E-02	3.35E-01	3.68E-01	1.48E+00		2.37E-04	
o-Nitrotoluene	88-72-2	137.14	EPI	8.99E-03	EPI	1	E	6.15E-01	4.05E-02	3.28E-01	3.61E-01	1.48E+00	4.45E-04	2.13E-03	
p-Nitrotoluene	99-99-0	137.14	EPI	1.00E-02	EPI	1	E	6.15E-01	4.50E-02	3.31E-01	3.64E-01	1.48E+00	6.12E-03	9.48E-03	

Chemical	CAS. NO.	MW (g/mole)	Ref.	Kp (cm/hr)	Ref.	FA (unitless)	Ref.	τ_{event} (hr/event)	B (unitless)	b	c	t* (hr)	DA_event carc	DA_event noncarc	DA_event mutagen
Pentachlorobenzene	608-93-5	250.34	EPI	1.68E-01	EPI	0.9	E	2.65E+00	1.02E+00	1.42E+00	1.19E+00	1.02E+01		1.90E-03	
Pentachlorophenol	87-86-5	266.34	EPI	1.27E-01	EPI	0.9	E	3.26E+00	7.97E-01	1.07E+00	9.83E-01	1.25E+01	2.45E-04	1.19E-02	
Perchlorate	14797-73-0	99.45	NIST	1.00E-03	E	1	E	3.79E-01	3.84E-03	3.06E-01	3.36E-01	9.08E-01		1.66E-03	
Perfluorinate chemicals (PFCs)		#REF!	#REF!												
Perfluorohexane sulfonic acid (PFHxS)		#REF!	#REF!												
Perfluorooctane sulfonate (PFO, PFOS)		#REF!	#REF!												
Perfluorooctanoic acid (PFOA)		0	0												
Phenanthrene	85-01-8	178.24	EPI	1.44E-01	EPI	1	E	1.05E+00	7.39E-01	9.95E-01	9.31E-01	4.04E+00		7.11E-02	
Phenol	108-95-2	94.11	EPI	4.34E-03	EPI	1	E	3.53E-01	1.62E-02	3.13E-01	3.44E-01	8.48E-01		7.11E-01	
Polychlorinatedbiphenyls		0	0												
Aroclor 1016	12674-11-2	257.55	EPI	3.05E-01	EPI	0.6	E	2.91E+00	1.88E+00	3.29E+00	2.00E+00	1.18E+01	1.40E-03	1.66E-04	
Aroclor 1221	11104-28-2	188.66	EPI	1.68E-01	EPI	0.6	E	1.20E+00	8.88E-01	1.20E+00	1.06E+00	4.60E+00	4.89E-05		
Aroclor 1232	11141-16-5	188.66	EPI	1.68E-01	EPI	0.6	E	1.20E+00	8.88E-01	1.20E+00	1.06E+00	4.60E+00	4.89E-05		
Aroclor 1242	53469-21-9	291.99	EPI	5.45E-01	EPI	0.6	E	4.53E+00	3.58E+00	9.71E+00	3.65E+00	1.94E+01	4.89E-05		
Aroclor 1248	12672-29-6	291.99	EPI	4.75E-01	EPI	0.6	E	4.53E+00	3.12E+00	7.61E+00	3.20E+00	1.92E+01	4.89E-05		
Aroclor 1254	11097-69-1	326.44	EPI	7.51E-01	EPI	0.6	E	7.07E+00	5.22E+00	1.93E+01	5.27E+00	3.10E+01	4.89E-05	4.74E-05	
Aroclor 1260	11096-82-5	395.33	EPI	9.86E-01	EPI	0.6	E	1.72E+01	7.54E+00	3.89E+01	7.58E+00	7.69E+01	4.89E-05		
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	35065-30-6	395.33	EPI	2.96E+00	EPI	0.6	E	1.72E+01	2.26E+01	3.33E+02	2.27E+01	7.95E+01	7.53E-06	1.66E-05	
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	35065-29-3	395.33	EPI	2.96E+00	EPI	0.6	E	1.72E+01	2.26E+01	3.33E+02	2.27E+01	7.95E+01	7.53E-05	1.66E-04	
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	39635-31-9	395.33	EPI	2.96E+00	EPI	0.6	E	1.72E+01	2.26E+01	3.33E+02	2.27E+01	7.95E+01	2.51E-05	5.53E-05	
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	52663-72-6	360.88	EPI	1.43E+00	EPI	0.5	E	1.10E+01	1.04E+01	7.30E+01	1.05E+01	5.00E+01	2.51E-05	5.53E-05	
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	69782-90-7	360.88	EPI	1.66E+00	EPI	0.5	E	1.10E+01	1.21E+01	9.76E+01	1.22E+01	5.02E+01	2.51E-05	5.53E-05	
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	38380-08-4	360.88	EPI	1.66E+00	EPI	0.5	E	1.10E+01	1.21E+01	9.76E+01	1.22E+01	5.02E+01	2.51E-05	5.53E-05	
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	32774-16-6	360.88	EPI	1.24E+00	EPI	0.5	E	1.10E+01	9.06E+00	5.53E+01	9.09E+00	4.97E+01	2.51E-08	5.53E-08	
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	65510-44-3	326.44	EPI	1.00E+00	EPI	0.6	E	7.07E+00	6.95E+00	3.32E+01	6.99E+00	3.15E+01	2.51E-05	5.53E-05	
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	31508-00-6	326.44	EPI	1.24E+00	EPI	0.6	E	7.07E+00	8.62E+00	5.02E+01	8.65E+00	3.18E+01	2.51E-05	5.53E-05	
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	32598-14-4	326.44	EPI	7.51E-01	EPI	0.6	E	7.07E+00	5.22E+00	1.93E+01	5.27E+00	3.10E+01	2.51E-05	5.53E-05	
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	74472-37-0	326.44	EPI	1.00E+00	EPI	0.6	E	7.07E+00	6.95E+00	3.32E+01	6.99E+00	3.15E+01	2.51E-05	5.53E-05	
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	57465-28-8	326.44	EPI	1.00E+00	EPI	0.6	E	7.07E+00	6.95E+00	3.32E+01	6.99E+00	3.15E+01	7.53E-09	1.66E-08	
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	32598-13-3	291.99	EPI	9.17E-01	EPI	0.6	E	4.53E+00	6.03E+00	2.54E+01	6.07E+00	2.01E+01	7.53E-06	1.66E-05	
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	70362-50-4	291.99	EPI	5.84E-01	EPI	0.6	E	4.53E+00	3.84E+00	1.10E+01	3.91E+00	1.95E+01	2.51E-06	5.53E-06	
Propylene oxide	75-56-9	58.08	EPI	7.74E-04	EPI	1	E	2.22E-01	2.27E-03	3.05E-01	3.35E-01	5.33E-01	4.08E-04		
Pyrene	129-00-0	202.26	EPI	2.01E-01	EPI	1	E	1.43E+00	1.10E+00	1.55E+00	1.26E+00	5.53E+00		7.11E-02	

Chemical	CAS. NO.	MW (g/mole)	Ref.	Kp (cm/hr)	Ref.	FA (unitless)	Ref.	τ_{event} (hr/event)	B (unitless)	b	c	t* (hr)	DA_event carc	DA_event noncarc	DA_event mutagen
RDX	121-82-4	222.12	EPI	3.36E-04	EPI	1	E	1.84E+00	1.93E-03	3.04E-01	3.35E-01	4.42E+00	8.90E-04	7.11E-03	
Selenium	7782-49-2	78.96	P	1.00E-03	E	1	E	2.91E-01	3.42E-03	3.05E-01	3.36E-01	6.98E-01		1.19E-02	
Silver	7440-22-4	107.87	P	6.00E-04	E	1	E	4.22E-01	2.40E-03	3.05E-01	3.35E-01	1.01E+00		4.74E-04	
Simazine	122-34-9	200	EPI	3.30E-03	EPI	1	E	1.38E+00	1.79E-02	3.14E-01	3.45E-01	3.40E+00	8.16E-04	1.19E-02	
Strontium	7440-24-6	87.62	P	1.00E-03	E	1	E	3.25E-01	3.60E-03	3.05E-01	3.36E-01	7.80E-01		1.42E+00	
Styrene	100-42-5	104.15	EPI	3.72E-02	EPI	1	E	4.02E-01	1.46E-01	3.99E-01	4.37E-01	9.65E-01		4.74E-01	
Sulfolane	126-33-0	120.17	EPI	1.02E-04	EPI	1	EPI	4.94E-01	4.30E-04	3.04E-01	3.34E-01	1.19E+00		2.37E-03	
2,3,7,8-TCDD	1746-01-6	321.98	EPI	8.08E-01	EPI	0.5	E	6.67E+00	5.58E+00	2.19E+01	5.63E+00	2.94E+01	7.53E-10	1.66E-09	
2,3,7,8-TCDF	51207-31-9	305.98	EPI	6.57E-01	EPI	1	E	5.43E+00	4.42E+00	1.42E+01	4.48E+00	2.36E+01	7.53E-09		
1,2,4,5-Tetrachlorobenzene	95-94-3	215.89	EPI	1.17E-01	EPI	1	E	1.70E+00	6.61E-01	8.95E-01	8.62E-01	6.66E+00		7.11E-04	
1,1,1,2-Tetrachloroethane	630-20-6	167.85	EPI	1.59E-02	EPI	1	E	9.14E-01	7.92E-02	3.53E-01	3.88E-01	2.19E+00	3.76E-03	7.11E-02	
1,1,2,2-Tetrachloroethane	79-34-5	167.85	EPI	6.94E-03	EPI	1	E	9.14E-01	3.46E-02	3.25E-01	3.57E-01	2.19E+00	4.89E-04	4.74E-02	
Tetrachloroethene	127-18-4	165.83	EPI	3.34E-02	EPI	1	E	8.91E-01	1.65E-01	4.13E-01	4.51E-01	2.14E+00	4.66E-02	1.42E-02	
Tetryl (Trinitrophenylmethylnitramine)	479-45-8	287.15	EPI	4.74E-04	EPI	1	E	4.26E+00	3.09E-03	3.05E-01	3.35E-01	1.02E+01		4.74E-03	
Thallium	7440-28-0	204.38	P	1.00E-03	E	1	E	1.46E+00	5.50E-03	3.07E-01	3.37E-01	3.52E+00		2.37E-05	
Toluene	108-88-3	92.14	EPI	3.11E-02	EPI	1	E	3.44E-01	1.15E-01	3.77E-01	4.14E-01	8.27E-01		1.90E-01	
Toxaphene	8001-35-2	413.82	EPI	5.18E-02	EPI	0.8	E	2.18E+01	4.05E-01	6.15E-01	6.42E-01	5.23E+01	8.90E-05		
Tribromomethane (Bromoform)	75-25-2	252.73	EPI	2.35E-03	EPI	1	E	2.73E+00	1.44E-02	3.12E-01	3.43E-01	6.56E+00	1.24E-02	4.74E-02	
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	187.38	EPI	1.75E-02	EPI	1	E	1.18E+00	9.21E-02	3.62E-01	3.97E-01	2.82E+00		7.11E+01	
1,2,4-Trichlorobenzene	120-82-1	181.45	EPI	7.05E-02	EPI	1	E	1.09E+00	3.65E-01	5.77E-01	6.09E-01	2.62E+00	3.37E-03	2.37E-02	
1,1,1-Trichloroethane	71-55-6	133.41	EPI	1.26E-02	EPI	1	E	5.87E-01	5.60E-02	3.38E-01	3.72E-01	1.41E+00		4.74E+00	
1,1,2-Trichloroethane	79-00-5	133.41	EPI	5.04E-03	EPI	1	E	5.87E-01	2.24E-02	3.17E-01	3.48E-01	1.41E+00	1.72E-03	9.48E-03	
Trichloroethylene	79-01-6	131.39	EPI	1.16E-02	EPI	1	E	5.71E-01	5.11E-02	3.35E-01	3.68E-01	1.37E+00		1.19E-03	6.78E-04
Trichlorofluoromethane	75-69-4	137.37	EPI	1.27E-02	EPI	1	E	6.17E-01	5.73E-02	3.39E-01	3.73E-01	1.48E+00		7.11E-01	
2,4,5-Trichlorophenol	95-95-4	197.45	EPI	3.62E-02	EPI	1	E	1.34E+00	1.96E-01	4.36E-01	4.74E-01	3.21E+00		2.37E-01	
2,4,6-Trichlorophenol	88-06-2	197.45	EPI	3.46E-02	EPI	1	E	1.34E+00	1.87E-01	4.29E-01	4.68E-01	3.21E+00	8.90E-03	2.37E-03	
1,1,2-Trichloropropane	598-77-6	147.43	EPI	9.60E-03	EPI	1	E	7.03E-01	4.48E-02	3.31E-01	3.64E-01	1.69E+00		1.19E-02	
1,2,3-Trichloropropane	96-18-4	147.43	EPI	7.52E-03	EPI	1	E	7.03E-01	3.51E-02	3.25E-01	3.57E-01	1.69E+00		9.48E-03	1.04E-06
Triethylamine	121-44-8	101.19	EPI	3.90E-03	EPI	1	E	3.87E-01	1.51E-02	3.13E-01	3.43E-01	9.29E-01			
2,4,6-Trinitrotoluene	118-96-7	227.13	EPI	9.63E-04	EPI	1	E	1.96E+00	5.58E-03	3.07E-01	3.37E-01	4.71E+00	3.26E-03	1.19E-03	
Uranium (soluable salts)	--	238.03	P	1.00E-03	E	1	E	2.26E+00	5.93E-03	3.07E-01	3.37E-01	5.42E+00		7.11E-03	
Vanadium	7440-62-2	50.94	EPI	1.00E-03	E	1	E	2.03E-01	2.75E-03	3.05E-01	3.35E-01	4.86E-01		3.11E-04	
Vinyl acetate	108-05-4	86.09	P	1.57E-03	EPI	1	E	3.19E-01	5.60E-03	3.07E-01	3.37E-01	7.65E-01		2.37E+00	

Chemical	CAS. NO.	MW (g/mole)	Ref.	Kp (cm/hr)	Ref.	FA (unitless)	Ref.	τ_{event} (hr/event)	B (unitless)	b	c	t* (hr)	DA_event carc	DA_event noncarc	DA_event mutagen
Vinyl bromide	593-60-2	106.95	EPI	4.35E-03	EPI	1	E	4.17E-01	1.73E-02	3.14E-01	3.45E-01	1.00E+00			
Vinyl chloride	75-01-4	62.5	EPI	8.38E-03	EPI	1	E	2.35E-01	2.55E-02	3.19E-01	3.51E-01	5.64E-01		7.11E-03	4.33E-05
m-Xylene	108-38-3	106.17	EPI	5.32E-02	EPI	1	E	4.13E-01	2.11E-01	4.47E-01	4.86E-01	9.91E-01		4.74E-01	
o-Xylene	95-47-6	106.17	EPI	5.00E-02	EPI	1	E	4.13E-01	1.98E-01	4.38E-01	4.76E-01	9.91E-01		4.74E-01	
p-Xylene	106-42-3	110	EPI	4.90E-02	EPI	1	E	4.10E-01	1.98E-01	4.37E-01	4.76E-01	9.90E-01		4.74E-01	
Xylenes	1330-20-7	106.17	EPI	5.00E-02	EPI	1	E	4.13E-01	1.98E-01	4.38E-01	4.76E-01	9.91E-01		4.74E-01	
Zinc	7440-66-6	65.38	P	6.00E-04	E	1	E	2.44E-01	1.87E-03	3.04E-01	3.35E-01	5.86E-01		7.11E-01	
Petroleum Hydrocarbons															
Aliphatics: C5 to C8	NA	93		0.166035	[a]	1		0.34833	0.6158403	0.8400	0.8221	1.39504		9.48E-02	
C9 to C12	NA	149		1.020469	[a]	1		0.71712	4.7909296	16.5005	4.8485	3.13416		2.37E-01	
C9 to C18	NA	170		1.473669	[a]	1		0.94013	7.3901136	37.3844	7.4298	4.20662		2.37E-01	
C19 to C36	NA	280			[b]	1		3.88320	0.00E+00	3.03E-01	3.33E-01	9.32E+00		4.74E+00	
Aromatics:C9 to C10	NA	120		0.132373	[a]	1		0.49339	0.5577214	0.7730	0.7717	1.18413		7.11E-02	
C11 to C22	NA	150		0.524083	[a]	1		0.72642	2.4687225	5.0950	2.5648	3.01891		6.54E-02	

K_p – Dermal permeability coefficient in water
FA – Fraction absorbed
T_{event} – Lag time per event
B – Ratio of the permeability coefficient of chemical through the stratum corneum relative to its permeability coefficient across the viable epidermis
b, c – Correlation coefficients (see RAGS Part E).
t* - Time to reach steady state
DA_{event} Carc. – Absorbed dose per event, carcinogens
DA_{event} Noncarc – Absorbed dose per event, noncarcinogens
DA_{event} Mutagens – Absorbed dose per event, mutagens

E = US EPA. 2004. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim Guidance. Office of Solid Waste and Emergency Response, Washington, D.C. http://www.epa.gov/oswer/riskassessment/ragse/index.htm
EPI= US EPA. 2012. Estimation Programs Interface (EPI) Suite™ for Microsoft® Windows, v 4.11. Washington, DC, USA.

[a]MCP toxicity.xlxs from Massachusetts Department of Environmental Protection

[b]Calculated using log Kow data from Sediment Toxicity of Petroleum Hydrocarbon Fractions, MDEP but found to be outside usable range. of empirical equation relating LogKp to LogKow and MW in EPA 2004.

APPENDIX C

TOXICITY DATA

Table C-1: Human Health Benchmarks Used for Calculating SSLs

Chemcial	SF_o (mg/kg-day)$^{-1}$	Reference	IUR (ug/m^3)$^{-1}$	Reference	RfD_o (mg/kg-day)	Reference	RfCi (mg/m^3)	Reference	Mutagen	GIABS	Ref	Dermal ABS	Ref
Acenaphthene					6.00E-02	IRIS				1	E	0.13	E
Acetaldehyde			2.20E-06	IRIS			9.00E-03	IRIS		1	E		
Acetone					9.00E-01	IRIS	3.10E+01	ATSDR		1	E		
Acetophenone					1.00E-01	IRIS				1	E		
Acrolein					5.00E-04	IRIS	2.00E-05	IRIS		1	E		
Acrylonitrile	5.40E-01	IRIS	6.80E-05	IRIS	4.00E-02	ATSDR	2.00E-03	IRIS		1	E		
Alachlor	5.60E-02	CalEPA			1.00E-02	IRIS				1	E	0.1	E
Aldrin	1.72E+01	IRIS	4.90E-03	IRIS	3.00E-05	IRIS				1	E	0.1	E
Aluminum					1.00E+00	PPRTV	5.00E-03	PPRTV		1	E		
Anthracene					3.00E-01	IRIS				1	E	0.13	E
Antimony					4.00E-04	IRIS				0.15	E		
Arsenic	9.00E-01	IRIS	4.30E-03	IRIS	1.80E-04	IRIS	1.50E-05	CalEPA		1	E	0.03	E
Atrazine	2.30E-01	CalEPA			3.50E-02	IRIS				1	E	0.1	E
Barium					2.00E-01	IRIS	5.00E-04	HEAST		0.07	E		
Benzene	5.50E-02	IRIS	7.80E-06	IRIS	4.00E-03	IRIS	3.00E-02	IRIS		1	E		
Benzidine	2.30E+02	IRIS	6.70E-02	IRIS	3.00E-03	IRIS			M	1	E	0.1	E
Benzo(a)anthracene	7.30E-01	PPRTV	1.10E-04	CalEPA					M	1	E	0.13	E
Benzo(a)pyrene	1.00E+00	IRIS	6.00E-04	IRIS	3.0E-04	IRIS	2.00E-06	IRIS	M	1	E	0.13	E
Benzo(b)fluoranthene	7.30E-01	EPA TEF	1.10E-04	CalEPA					M	1	E	0.13	E
Benzo(k)fluoranthene	7.30E-02	EPA TEF	1.10E-04	CalEPA					M	1	E	0.13	E
Beryllium			2.40E-03	IRIS	2.00E-03	IRIS	2.00E-05	IRIS		0.007	E		
a-BHC (HCH)	6.30E+00	IRIS	1.80E-03	IRIS	8.00E-03	ATSDR				1	E	0.1	E
b-BHC (HCH)	1.80E+00	IRIS	5.30E-04	IRIS						1	E	0.1	E
g-BHC	1.10E+00	CalEPA	3.10E-04	CalEPA	3.00E-04	IRIS				1	E	0.04	E
1,1-Biphenyl	8.20E-03	IRIS			5.00E-01	IRIS	4.00E-04	PPRTV		1	E		
Bis(2-chloroethyl) ether	1.10E+00	IRIS	3.30E-04	IRIS						1	E		
Bis(2-chloroisopropyl) ether	7.00E-02	HEAST								1	E		
Bis(2-ethylhexyl) phthalate	1.40E-02	IRIS	2.40E-06	CalEPA	2.00E-02	IRIS				1	E	0.1	E
Bis(chloromethyl) ether	2.20E+02	IRIS	6.20E-02	IRIS						1	E		
Boron					2.00E-01	IRIS	2.00E-02	HEAST		1	E		
Bromodichloromethane	6.20E-02	IRIS	3.70E-05	CalEPA	2.00E-02	IRIS				1	E		
Bromomethane					1.40E-03	IRIS	5.00E-03	IRIS		1	E		

Chemcial	SF_o (mg/kg-day)$^{-1}$	Reference	IUR (ug/m^3)$^{-1}$	Reference	RfD_o (mg/kg-day)	Reference	RfCi (mg/m^3)	Reference	Mutagen	GIABS	Ref	Dermal ABS	Ref
1,3-Butadiene	3.40E+00	CalEPA	3.00E-05	IRIS			2.00E-03	IRIS		1	E		
2-Butanone (Methyl ethyl ketone, MEK)					6.00E-01	IRIS	5.00E+00	IRIS		1	E		
tert-Butyl methyl ether (MTBE)	1.80E-03	CalEPA	2.60E-07	CalEPA			3.00E+00	IRIS		1	E		
Cadmium			1.80E-03	IRIS	1.00E-03	IRIS	1.00E-05	ATSDR		0.025	E	0.001	E
Carbofuran					5.00E-03	IRIS				1	E	0.100	E
Carbon disulfide					1.00E-01	IRIS	7.00E-01	IRIS		1	E		
Carbon tetrachloride	7.00E-02	IRIS	6.00E-06	IRIS	4.00E-03	IRIS	1.00E-01	IRIS		1	E		
Chlordane	3.50E-01	IRIS	1.00E-04	IRIS	5.00E-04	IRIS	7.00E-04	IRIS		1	E	0.04	E
2-Chloroacetophenone							3.00E-05	IRIS		1	E	0.1	E
2-Chloro-1,3-butadiene			3.00E-04	IRIS	2.00E-02	HEAST	2.00E-02	IRIS		1	E		
1-Chloro-1,1-difluoroethane							5.00E+01	IRIS		1	E		
Chlorobenzene					2.00E-02	IRIS	5.00E-02	PPRTV		1	E		
1-Chlorobutane					4.00E-02	PPRTV				1	E		
Chlorodifluoromethane							5.00E+01	IRIS		1	E		
Chloroform	1.90E-02	CalEPA	2.30E-05	IRIS	1.00E-02	IRIS	9.80E-02	ATSDR		1	E		
Chloromethane	1.30E-02	HEAST	1.80E-06	HEAST			9.00E-02	IRIS		1	E		
b-Chloronaphthalene					8.00E-02	IRIS				1	E		
o-Chloronitrobenzene	3.00E-01	PPRTV			3.00E-03	PPRTV	1.00E-05	PPRTV		1	E	0.1	E
p-Chloronitrobenzene	6.30E-03	PPRTV			1.00E-03	PPRTV	6.00E-04	PPRTV		1	E	0.1	E
2-Chlorophenol					5.00E-03	IRIS				1	E		
2-Chloropropane							1.00E-01	HEAST		1	E		
o-Chlorotoluene					2.00E-02	IRIS				1	E		
Chromium III					1.50E+00	IRIS				0.013	E		
Chromium VI	5.00E-01	NJ	8.40E-02	IRIS	3.00E-03	IRIS	1.00E-04	IRIS	M	0.025	E		
Chromium (Total)	7.14E-02	NJ, adj.	1.20E-02	IRIS	1.29E+00	IRIS, adj.	1.43E-05	IRIS, adj.		0.013	E		
Chrysene	7.30E-03	EPA TEF	1.10E-05	CalEPA					M	1	E	0.13	E
Cobalt			9.00E-03	PPRTV	3.0E-04	PPRTV	6.00E-06	PPRTV		1	E		
Copper					4.00E-02	HEAST				1	E		
Crotonaldehyde	1.90E+00	HEAST			1.00E-03	PPRTV				1	E		
Cumene (isopropylbenzene)					1.00E-01	IRIS	4.00E-01	IRIS		1	E		
Cyanide					6.00E-04	IRIS	8.00E-04	IRIS		1	E		
Cyanogen					1.00E-03	IRIS				1	E		
Cyanogen bromide					9.00E-02	IRIS				1	E		
Cyanogen chloride					5.00E-02	IRIS				1	E		
DDD	2.40E-01	IRIS	6.90E-05	CalEPA						1	E	0.1	E
DDE	3.40E-01	IRIS	9.70E-05	CalEPA						1	E	0.1	E

Chemcial	SF_o (mg/kg-day)$^{-1}$	Reference	IUR (ug/m^3)$^{-1}$	Reference	RfD_o (mg/kg-day)	Reference	RfCi (mg/m^3)	Reference	Mutagen	GIABS	Ref	Dermal ABS	Ref
DDT	3.40E-01	IRIS	9.70E-05	IRIS	5.00E-04	IRIS				1	E	0.03	E
Dibenz(a,h)anthracene	7.30E+00	EPA TEF	1.20E-03	CalEPA					M	1	E	0.13	E
1,2-Dibromo-3-chloropropane	8.00E-01	PPRTV	6.00E-03	PPRTV	2.00E-04	PPRTV	2.00E-04	IRIS	M	1	E	0.1	E
Dibromochloromethane	8.40E-02	IRIS	2.70E-05	CalEPA	2.00E-02	IRIS				1	E	0.1	E
1,2-Dibromoethane	2.00E+00	IRIS	6.00E-04	IRIS	9.00E-03	IRIS	9.00E-03	IRIS		1	E		
1,4-Dichloro-2-butene			4.20E-03	PPRTV						1	E		
1,2-Dichlorobenzene					9.00E-02	IRIS	2.00E-01	HEAST		1	E		
1,4-Dichlorobenzene	5.40E-03	CalEPA	1.10E-05	CalEPA	7.00E-02	ATSDR	8.00E-01	IRIS		1	E		
3,3-Dichlorobenzidine	4.50E-01	IRIS	3.40E-04	CalEPA						1	E	0.1	E
Dichlorodifluoromethane					2.00E-01	IRIS	1.00E-01	PPRTV		1	E		
1,1-Dichloroethane	5.70E-03	CalEPA	1.60E-06	CalEPA	2.00E-01	PPRTV				1	E		
1,2-Dichloroethane	9.10E-02	IRIS	2.60E-05	IRIS	6.00E-03	PPRTV	7.00E-03	PPRTV		1	E		
cis-1,2-Dichloroethene					2.00E-03	IRIS				1	E		
trans-1,2-Dichloroethene					2.00E-02	IRIS	6.00E-02	PPRTV		1	E		
1,1-Dichloroethene					5.00E-02	IRIS	2.00E-01	IRIS		1	E		
2,4-Dichlorophenol					3.00E-03	IRIS				1	E	0.1	E
1,2-Dichloropropane	3.60E-02	CalEPA	1.00E-05	CalEPA	9.00E-02	ATSDR	4.00E-03	IRIS		1	E		
1,3-Dichloropropene	1.00E-01	IRIS	4.00E-06	IRIS	3.00E-02	IRIS	2.00E-02	IRIS		1	E		
Dicyclopentadiene					8.00E-02	PPRTV	3.00E-04	PPRTV		1	E		
Dieldrin	1.60E+01	IRIS	4.60E-03	IRIS	5.00E-05	IRIS				1	E	0.1	E
Diethyl phthalate					8.00E-01	IRIS				1	E	0.1	E
Di-n-butyl phthalate (Dibutyl phthalate)					1.00E-01	IRIS				1	E	0.1	E
2,4-Dimethylphenol					2.00E-02	IRIS				1	E	0.1	E
Dimethyl phthalate					1.00E+00	HEAST				1	E	0.1	E
4,6-Dinitro-o-cresol					8.00E-05	PPRTV				1	E	0.1	E
2,4-Dinitrophenol					2.00E-03	IRIS				1	E	0.1	E
2,4-Dinitrotoluene	3.10E-01	CalEPA	8.90E-05	CalEPA	2.00E-03	IRIS				1	E	0.102	E
2,6-Dintitrotoluene	1.50E+00	PPRTV			3.00E-04	PPRTV				1	E	0.099	E
2,4/2,6-Dintrotoluene Mixture	6.80E-01	IRIS								1	E	0.1	E
1,4-Dioxane	1.00E-01	IRIS	5.00E-06	IRIS	3.00E-02	IRIS	3.00E-02	IRIS		1	E	0.1	E
1,2-Diphenylhydrazine	8.00E-01	IRIS	2.20E-04	IRIS						1	E	0.1	E
Endosulfan					6.00E-03	IRIS				1	E	0.1	E
Endrin					3.00E-04	IRIS				1	E	0.1	E
Epichlorohydrin	9.90E-03	IRIS	1.20E-06	IRIS	6.00E-03	PPRTV	1.00E-03	IRIS		1	E		
Ethyl acetate					9.00E-01	IRIS	7.00E-02	PPRTV		1	E		
Ethyl acrylate	4.80E-02	HEAST								1	E		

Chemcial	SF_o (mg/kg-day)$^{-1}$	Reference	IUR (ug/m^3)$^{-1}$	Reference	RfD_o (mg/kg-day)	Reference	RfCi (mg/m^3)	Reference	Mutagen	GIABS	Ref	Dermal ABS	Ref
Ethyl chloride							1.00E+01	IRIS		1	E		
Ethyl ether					2.00E-01	IRIS				1	E		
Ethyl methacrylate					9.00E-02	HEAST	3.00E-01	PPRTV		1	E		
Ethylbenzene	1.10E-02	CalEPA	2.50E-06	CalEPA	1.00E-01	IRIS	1.00E+00	IRIS		1	E		
Ethylene oxide	3.10E-01	CalEPA	3.00E-03	IRIS			3.00E-02	CalEPA		1	E		
Fluoranthene					4.00E-02	IRIS				1	E	0.13	E
Fluorene					4.00E-02	IRIS				1	E	0.13	E
Fluoride					6.00E-02	IRIS	1.30E-02	CalEPA		1	E		
Furan					1.00E-03	IRIS				1	E	0.03	
Glyphosate					1.00E-01	IRIS				1	E	0.1	E
Heptachlor	4.50E+00	IRIS	1.30E-03	IRIS	5.00E-04	IRIS				1	E	0.1	E
Hexachlorobenzene	1.60E+00	IRIS	4.60E-04	IRIS	8.00E-04	IRIS				1	E	0.1	E
Hexachloro-1,3-butadiene	7.80E-02	IRIS	2.20E-05	IRIS	1.00E-03	PPRTV				1	E	0.1	E
Hexachlorocyclopentadiene					6.00E-03	IRIS	2.00E-04	IRIS		1	E	0.1	E
Hexachloroethane	4.00E-02	IRIS	1.10E-05	CalEPA	7.00E-04	IRIS	3.00E-02	IRIS		1	E	0.1	E
n-Hexane					6.00E-02	HEAST	7.00E-01	IRIS		1	E		
HMX					5.00E-02	IRIS				1	E	0.006	E
Hydrazine anhydride	3.00E+00	IRIS	4.90E-03	IRIS			3.00E-05	PPRTV		1	E	0.1	E
Hydrogen cyanide					6.00E-04	IRIS	8.00E-04	IRIS		1	E		
Indeno(1,2,3-c,d)pyrene	7.30E-01	EPA TEF	1.10E-04	CalEPA					M	1	E	0.13	E
Iron					7.00E-01	PPRTV				1	E		
Isobutanol (Isobutyl alcohol)					3.00E-01	IRIS				1	E	0.1	E
Isophorone	9.50E-04	IRIS			2.00E-01	IRIS	2.00E+00	CalEPA		1	E	0.1	E
Lead										1	E		
Lead (tetraethyl-)					1.00E-07	IRIS				1	E	0.1	
Maleic hydrazide					5.00E-01	IRIS				1	E	0.1	E
Manganese					1.40E-01	IRIS	5.00E-05	IRIS		0.04	E		
Mercury (elemental)							3.00E-04	IRIS		1	E		
Mercury (methyl)					1.00E-04	IRIS				1	E		
Mercuric Chloride (Mercury Salts)					3.00E-04	IRIS	3.00E-05	CalEPA		0.07	E		
Methacrylonitrile					1.00E-04	IRIS	3.00E-02	PPRTV		1	E		
Methomyl					2.50E-02	IRIS				1	E	0.1	E
Methyl acetate					1.00E+00	PPRTV				1	E		
Methyl acrylate					3.00E-02	HEAST	2.00E-02	PPRTV		1	E		
Methyl isobutyl ketone					8.00E-02	HEAST	3.00E+00	IRIS		1	E		
Methyl methacrylate					1.40E+00	IRIS	7.00E-01	IRIS		1	E		

Chemcial	SF_o (mg/kg-day)$^{-1}$	Reference	IUR (ug/m^3)$^{-1}$	Reference	RfD_o (mg/kg-day)	Reference	RfCi (mg/m^3)	Reference	Mutagen	GIABS	Ref	Dermal ABS	Ref
Methyl styrene (alpha)					7.00E-02	HEAST				1	E		
Methyl styrene (mixture)					6.00E-03	HEAST	4.00E-02	HEAST		1	E		
Methylcyclohexane							3.00E+00	HEAST		1	E		
Methylene bromide (Dibromomethane)					1.00E-02	HEAST	4.00E-03	PPRTV		1	E		
Methylene chloride	2.00E-03	IRIS	1.00E-08	IRIS	6.00E-03	IRIS	6.00E-01	IRIS	M	1	E		
1-Methylnaphthalene	2.90E-02	PPRTV			7.00E-02	ASTDR				1	E	0.13	E
2-Methylnaphthalene					4.00E-03	iRIS				1	E	0.13	E
Molybdenum					5.00E-03	IRIS				1	E		
Naphthalene			3.40E-05	CalEPA	2.00E-02	IRIS	3.00E-03	IRIS		1	E	0.13	E
Nickel (soluble salts)			2.60E-04	CalEPA	2.00E-02	IRIS	9.00E-05	ATSDR		0.04	E		
Nitrate					1.60E+00	IRIS				1	E		
Nitrite					1.00E-01	IRIS				1	E		
Nitrobenzene			4.00E-05	IRIS	2.00E-03	IRIS	9.00E-03	IRIS		1	E		
Nitroglycerin	1.70E-02	PPRTV			1.00E-04	PPRTV				1	E	0.1	E
Nitrophenol													
N-Nitrosodiethylamine	1.50E+02	IRIS	4.30E-02	IRIS					M	1	E	0.1	E
N-Nitrosodimethylamine	5.10E+01	IRIS	1.40E-02	IRIS	8.00E-06	PPRTV	4.00E-05	PPRTV	M	1	E	0.1	E
N-Nitrosodi-*n*-butylamine	5.40E+00	IRIS	1.60E-03	IRIS						1	E	0.1	E
N-Nitrosodiphenylamine	4.90E-03	IRIS	2.60E-06	CalEPA						1	E	0.1	E
N-Nitrosopyrrolidine	2.10E+00	IRIS	6.10E-04	IRIS						1	E	0.1	E
m-Nitrotoluene					1.00E-04	PPRTV				1	E	0.1	E
o-Nitrotoluene	2.20E-01	PPRTV			9.00E-04	PPRTV				1	E		
p-Nitrotoluene	1.60E-02	PPRTV			4.00E-03	PPRTV				1	E	0.1	E
Pentachlorobenzene					8.00E-04	IRIS				1	E	0.1	E
Pentachlorophenol	4.00E-01	IRIS	5.10E-06	CalEPA	5.00E-03	IRIS				1	E	0.25	E
Perchlorate					7.00E-04	IRIS				1	E		
Perfluorinate chemicals (PFCs)													
Perfluorohexane sulfonic acid (PFHxS)													
Perfluorooctane sulfonate (PFO, PFOS)													
Perfluorooctanoic acid (PFOA)													
Phenanthrene					3.00E-02	IRIS				1	E	0.13	E
Phenol					3.00E-01	IRIS	2.00E-01	CalEPA		1	E	0.1	E
Polychlorinatedbiphenyls											E		
Aroclor 1016	7.00E-02	IRIS	2.00E-05	IRIS	7.00E-05	IRIS				1	E	0.14	E
Aroclor 1221	2.00E+00	IRIS	5.70E-04	IRIS						1	E	0.14	E
Aroclor 1232	2.00E+00	IRIS	5.70E-04	IRIS						1	E	0.14	E

Chemcial	SF_o (mg/kg-day)$^{-1}$	Reference	IUR (ug/m^3)$^{-1}$	Reference	RfD_o (mg/kg-day)	Reference	RfCi (mg/m^3)	Reference	Mutagen	GIABS	Ref	Dermal ABS	Ref
Aroclor 1242	2.00E+00	IRIS	5.70E-04	IRIS						1	E	0.14	E
Aroclor 1248	2.00E+00	IRIS	5.70E-04	IRIS						1	E	0.14	E
Aroclor 1254	2.00E+00	IRIS	5.70E-04	IRIS	2.00E-05	IRIS				1	E	0.14	E
Aroclor 1260	2.00E+00	IRIS	5.70E-04	IRIS						1	E	0.14	E
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	1.30E+01	WHO TEF	3.80E-03	WHO TEF	7.00E-06	WHO TEF	4.00E-04	WHO TEF		1	E	0.14	E
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	1.30E+00	WHO TEF	3.80E-04	WHO TEF	7.00E-05	WHO TEF	4.00E-03	WHO TEF		1	E	0.14	E
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	3.90E+03	WHO TEF	1.14E+00	WHO TEF	2.33E-08	WHO TEF	1.33E-06	WHO TEF		1	E	0.14	E
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	1.30E+04	WHO TEF	3.80E+00	WHO TEF	7.00E-09	WHO TEF	4.00E-07	WHO TEF		1	E	0.14	E
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	1.30E+01	WHO TEF	3.80E-03	WHO TEF	7.00E-06	WHO TEF	4.00E-04	WHO TEF		1	E	0.14	E
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	3.90E+01	WHO TEF	1.14E-02	WHO TEF	2.33E-06	WHO TEF	1.33E-04	WHO TEF		1	E	0.14	E
Propylene oxide	2.40E-01	IRIS	3.70E-06	IRIS			3.00E-02	IRIS		1	E		
Pyrene					3.00E-02	IRIS				1	E	0.13	E
RDX	1.10E-01	IRIS			3.00E-03	IRIS				1	E	0.015	E
Selenium					5.00E-03	IRIS	2.00E-02	CalEPA		1	E		
Silver					5.00E-03	IRIS				0.04	E		
Simazine	1.20E-01	HEAST			5.00E-03	IRIS				1	E	0.1	E
Strontium					6.00E-01	IRIS				1	E		
Styrene					2.00E-01	IRIS	1.00E+00	IRIS		1	E		
Sulfolane					1.00E-03	PPRTV	2.00E-03	PPRTV		1	E	0.1	E
2,3,7,8-TCDD	1.30E+05	CalEPA	3.80E+01	CalEPA	7.00E-10	IRIS	4.00E-08	CalEPA		1	E	0.03	E
2,3,7,8-TCDF	1.30E+04	WHO TEF	3.80E+00	WHO TEF						1	E	0.03	E
1,2,4,5-Tetrachlorobenzene					3.00E-04	IRIS				1	E	0.1	E
1,1,1,2-Tetrachloroethane	2.60E-02	IRIS	7.40E-06	IRIS	3.00E-02	IRIS				1	E		
1,1,2,2-Tetrachloroethane	2.00E-01	IRIS	5.80E-05	CalEPA	2.00E-02	IRIS				1	E		
Tetrachloroethene	2.10E-03	IRIS	2.60E-07	IRIS	6.00E-03	IRIS	4.00E-02	IRIS		1	E		
Tetryl (Trinitrophenylmethylnitramine)					2.00E-03	PPRTV				1	E	0.00065	E
Thallium					1.00E-05	PPRTV				1	E		
Toluene					8.00E-02	IRIS	5.00E+00	IRIS		1	E		

Chemcial	SF_o (mg/kg-day)$^{-1}$	Reference	IUR (ug/m^3)$^{-1}$	Reference	RfD_o (mg/kg-day)	Reference	RfCi (mg/m^3)	Reference	Mutagen	GIABS	Ref	Dermal ABS	Ref
Toxaphene	1.10E+00	IRIS	3.20E-04	IRIS						1	E	0.1	E
Tribromomethane (Bromoform)	7.90E-03	IRIS	1.10E-06	IRIS	2.00E-02	IRIS				1	E	0.1	E
1,1,2-Trichloro-1,2,2-trifluoroethane					3.00E+01	IRIS	3.00E+01	HEAST		1	E		
1,2,4-Trichlorobenzene	2.90E-02	PPRTV			1.00E-02	IRIS	2.00E-03	PPRTV		1	E		
1,1,1-Trichloroethane					2.00E+00	IRIS	5.00E+00	IRIS		1	E		
1,1,2-Trichloroethane	5.70E-02	IRIS	1.60E-05	IRIS	4.00E-03	IRIS	2.00E-04	PPRTV		1	E		
Trichloroethylene	4.6E-02	IRIS	4.10E-06	IRIS	5.00E-04	IRIS	2.00E-03	IRIS	M	1	E		
Trichlorofluoromethane					3.00E-01	IRIS	7.00E-01	HEAST		1	E		
2,4,5-Trichlorophenol					1.00E-01	IRIS				1	E	0.1	E
2,4,6-Trichlorophenol	1.10E-02	IRIS	3.10E-06	IRIS	1.00E-03	PPRTV				1	E	0.1	E
1,1,2-Trichloropropane					5.00E-03	IRIS				1	E		
1,2,3-Trichloropropane	3.00E+01	IRIS			4.00E-03	IRIS	3.00E-04	IRIS	M	1	E		
Triethylamine							7.00E-03	IRIS		1	E		
2,4,6-Trinitrotoluene	3.00E-02	IRIS			5.00E-04	IRIS				1	E	0.032	E
Uranium (soluable salts)					3.00E-03	IRIS	4.00E-05	ATSDR		1	E		
Vanadium					5.04E-03	IRIS	1.00E-04	ATSDR		0.026	E		
Vinyl acetate					1.00E+00	HEAST	2.00E-01	IRIS		1	E		
Vinyl bromide			3.20E-05	HEAST			3.00E-03	IRIS		1	E		
Vinyl chloride	7.20E-01	IRIS	4.40E-06	IRIS	3.00E-03	IRIS	1.00E-01	IRIS	M	1	E		
m-Xylene					2.00E-01	IRIS	1.00E-01	IRIS		1	E		
o-Xylene					2.00E-01	IRIS	1.00E-01	IRIS		1	E		
p-Xylene					2.00E-01	iRIS	1.00E-01	IRIS		1	E		
Xylenes					2.00E-01	IRIS	1.00E-01	IRIS		1	E		
Zinc					3.00E-01	IRIS				1	E		
Petroleum Hydrocarbons					3.00E-01	IRIS				1	E		
Aliphatics: C5 to C8					4.00E-02	a	2.0E-01	a		1			
C9 to C12					1.00E-01	a	2.0E-01	a		1			
C9 to C18					1.00E-01	a	2.0E-01	a		1			
C19 to C36					2.00E+00	a				1			
Aromatics: C9 to C10					3.00E-02	a	5.0E-02	a		1			
C11 to C22					3.00E-02	a	5.0E-02	a		0.92			

Notes:
CSF_o – Oral Cancer Slope Factor
IUR– Inhalation Unit Risk
RfD_o – Oral Reference Dose
RfC – Inhalation Reference Concentration

Dermal ABS – Dermal absorption coefficient
GIABS – Gastrointestinal absorption coefficient adjusted – Toxicity data for total chromium has been adjusted based on a ratio of 6:1 (CrIII:CrVI)
E = US EPA. 2004. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim Guidance. Office of Solid Waste and Emergency Response, Washington, D.C. http://www.epa.gov/oswer/riskassessment/ragse/index.htm
EPA TEF – US EPA (1993) toxicity equivalency factors applied to polycyclic aromatic hydrocarbons
ATSDR – Agency for Toxic Substances and Disease Registry
Cal EPA – California Environmental Protection Agency
HEAST – Health Effects Assessment Summary Tables
IRIS – Integrated Risk Information System
PPTRV – Provisional Peer Reviewed Toxicity Value
NJ – New Jersey Department of Environmental Protection (2009)
WHO TEF – World Health Organization Toxicity Equivalency Factor
a - Final Updated Petroleum Hydrocarbon Fraction Toxicity Values for the VPH/EPH/APH Methodology.

-Toxicity data for total chromium has been adjusted based on a ratio of 6:1 (CrIII:CrVI)

-For GI absorption, a value of 1 was used for all organics as directed in RAGS Part E. A default value of 1 was used for inorganics not listed in RAGS Part E.
-Pyrene toxicity data used as surrogate data for phenanthrene.
-Aroclor 1016 is considered the lowest risk, so it was assigned a "lowest risk" value from IRIS. All other Aroclors were assigned a "highest risk" value from IRIS.
-Toxicity data for total xylenes used as a surrogate for all other isomers of xylene (o-, m-, and p-xylene)
-The RfDo value for vanadium is based on RfD for vanadium pentoxide and adjusted for molecular weight.
-The RfDo value for cadmium is based on the RfDo for food. An RfDo of 0.0005 mg/kg-d was used for the tap water pathways as directed in IRIS (US EPA, 2014).

APPENDIX D

Guidance for Risk-based Remediation of Polychlorinated Biphenyls (PCBs) at RCRA Corrective Action Sites

Guidance for Risk-based Remediation of Polychlorinated Biphenyls (PCBs) at RCRA Corrective Action Sites[1]

Table of Contents

List of Tables

[1]This document is intended as guidance for employees of the New Mexico Environment Department's (NMED) Hazardous Waste Bureau (HWB) and Resource Conservation and Recovery Act (RCRA)-regulated facilities within the State of New Mexico. This guidance does not constitute rule-making and may not be relied upon to create a right or benefit, substantive or procedural, enforceable at law or in equity, by any person. HWB may take action at variance to this guidance and reserves the right to modify this guidance at any time without public notice.

ACRONYMNS AND ABBREVIATIONS

µg/g	microgram per gram
µg/L	microgram per liter
AOC	Area of Concern
AT	Averaging Time
BMP	Best Management Practices
BW	Body Weight
CSF	Cancer Slope Factor
CWA	Clean Water Act
DD	Daily Dose
ECD	Electron Capture Detector
ED	Exposure Duration
EF	Exposure Frequency
ELCD	Electrolytic Conductivity Detector
GC/MS	Gas Chromatography/Mass Spectral Detector
HR	High Resolution
HRGC	High Resolution Gas Chromatography
HRMS	High Resolution Mass Spectral Detector
HWB	Hazardous Waste Bureau
IR	Ingestion Rate
IRIS	Integrated Risk Information System
LADD	Lifetime Average Daily Dose
mg/m^3	milligram per cubic meter
mg/kg	milligram per kilogram
mg/L	milligram per liter
ng/L	nanogram per liter
NMED	New Mexico Environment Department
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzo-dioxins
PCDF	Polychlorinated Dibenzo-furans
pg/L	picogram per liter
ppb	parts per billion
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
SWMU	Solid Waste Management Unit
TCDD	2,3,7,8-tetrachloro-dibenzo-dioxin
TCDF	2,3,7,8-tetrachloro-dibenzo-furan
TEF	Toxicity Equivalency Factor
TEQ	Toxicity Equivalency Quotient
TRV	Toxicity Reference Value

TSS Total Suspended Solids
US EPA United States Environmental Protection Agency

Guidance for Risk-based Remediation of Polychlorinated Biphenyls at RCRA Corrective Action Sites

1.0 SCOPE

This document focuses on remedial activities at sites where polychlorinated biphenyls (**PCBs**) have been identified or are suspected of being present as one of the contaminants of potential concern. The intent of this document is to expedite the remedial action process and provide a cost-effective and consistent method for the evaluation and reduction of the risk posed to human health and the environment by PCBs.

This document **does not** discuss the complex regulations governing PCBs or the sampling methodologies for PCBs or other associated contaminants. This document **does** assume that the nature and extent of PCB contamination have been defined using a site conceptual model and **does** discuss and recommend analytical methods applicable to evaluating the risk to human and ecological health for PCBs in environmental media.

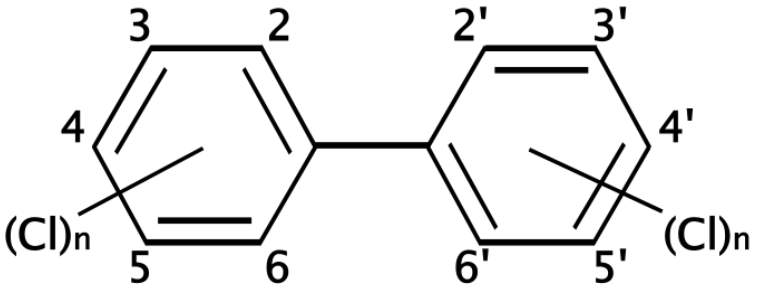
This paper **does not** discuss the risk posed to ground water quality by PCB contamination; state ground water standards and federal drinking water standards[2] exist for the protection of ground water. No state or federal soil/sediment standards exist to protect ground water from the transport of PCBs from contaminated soil/sediments; however, the risk associated with the transport of PCBs from contaminated soil/sediments to ground water should be evaluated to ensure that state and federal standards for ground water are not exceeded. Methods for the evaluation of this threat to ground water are **not**, at this time, specifically addressed in this document.

2.0 BACKGROUND INFORMATION

PCBs are a class of chlorinated organic compounds which found widespread application since their introduction into commerce in 1923. Their properties include thermal stability; resistance to acids, bases and oxidation; and resistance to direct electrical current. They were commonly used in transformers and capacitors, hydraulic and heat transfer equipment, compressors and vacuum pumps, plasticizers (surface coatings and sealants), and some paints and inks. Domestic production of commercial PCBs ceased in 1977; however, PCBs in existence at that time are still in use today.

The general chemical structure of chlorinated biphenyls is as follows:

[2]PCBs in ground water may not exceed the Safe Drinking Water Act's maximum contaminant level of 0.5 micrograms per liter (µg/L) in drinking water (Title 40 Code of Federal Regulations Parts 141-147 and 149) or the State of New Mexico's Water Quality Control Commission Regulations' standard of 0.5 µg/L in ground water with 10,000 milligrams per liter (mg/L) or less total dissolved solids (Title 20 New Mexico Annotated Code Chapter 6.2).



The number and position of chlorines in the biphenyl molecule determine the physical and chemical properties of the PCB molecule. There are a total of 209 possible *congeners*[3] of PCBs, each one resulting from the chlorination of different substitution positions and varying degrees of chlorination. In general, PCB molecules with higher degrees of chlorination are more resistant to biodegradation and are more persistent in the environment.

PCB congeners may be found in commercial preparations or complex mixtures known by the names Askarel, Aroclor, Clophen, Phenoclor, Kanechlor, and Pyralène. In the United States, PCB mixtures were marketed under the trade name of Aroclor. Each Aroclor has a four-digit numeric designation: the first two digits are "12" (indicating the biphenyl parent molecule) followed by two more digits indicating the percent chlorine content by weight in the mixture. For example, Aroclor 1254 has 54% chlorine by weight. Aroclor 1016 is the exception: it contains 41% chlorine by weight (ATSDR, 1995).

PCBs are a group of environmentally persistent organic chemicals that possess the inherent properties of compounds that bioaccumulate (i.e., high octanol/water partition coefficient and low water solubility). PCBs also have the following properties of environmental relevance: low vapor pressure and low flammability.

PCBs are toxic to humans and other animals (Eisler, 1986; ATSDR, 1995; and US EPA, 1996 and 1997a). PCBs adversely impact reproduction in wildlife and in experimental animals. Other common toxic effects in mammals and birds include thymic atrophy (a wasting syndrome), microsomal enzyme induction, porphyria (manifestations include intermittent nervous system dysfunction and/or sensitivity of skin to sunlight) and related liver damage, chloracne, estrogenic activity, immunosuppression, and tumor promotion. PCBs can be transferred to young mammals (including humans) transplacentally and in breast milk.

The United States Environmental Protection Agency (**US EPA**) and International Agency for Research on Cancer classified PCBs as Group B2; probable human carcinogens, based on sufficient evidence of carcinogenicity (manifested as hepatocellular carcinomas) in experimental animals and inadequate (due to confounding exposures to other potential carcinogens or lack of exposure quantification), yet suggestive evidence of excess risk of liver cancer in humans (US EPA, 2010 and US EPA, 2016). Recent studies have indicated that all PCB mixtures can cause cancer; however, different mixtures exhibit different carcinogenic potencies (Cogliano, 1998).

[3]*Congener* means any single, unique, well-defined chemical compound in the PCB category.

In addition, environmental processes may alter the PCB mixtures affecting its carcinogenic potency (see *Environmental Processes*).

The stability and lipophilicity of PCBs promote their biomagnification (i.e., the uptake of a chemical through ingestion resulting in the concentration of the chemical in tissue being greater than that of its food) once they enter the aquatic and terrestrial food chains. Through the food chain, living organisms selectively bioaccumulate persistent congeners of PCBs. Environmentally aged PCB mixtures appear to be more toxic and persistent in the organism than commercial PCB mixtures. Biomagnification through trophic transfer governs PCB levels in animals, especially those occupying the top of the food web. Therefore, PCBs in food sources represent the most important exposure source to humans and wildlife.

In certain situations, PCBs can become contaminated with the far more toxic polychlorinated dibenzofurans (**PCDFs**) and chlorinated dibenzo-dioxins (**PCDDs**). Therefore, the presence of PCDFs and PCDDs should always be investigated if any of the following processes existed or are suspected of existing:

- Combustion or incineration of PCB-contaminated waste or waste oils, or highly variable waste streams (such as municipal and commercial waste for which PCB contamination is suspected);
- Manufacture of PCBs[4];
- Pyrolysis of PCBs;
- Photolysis of PCBs;
- Incidental fire of transformers and capacitors containing PCBs; or
- Treatment with chlorinating compounds (e.g., hydrochloric acid, chlorine, etc.).

3.0 ENVIRONMENTAL PROCESSES

PCBs occur as mixtures of congeners in the environment. *Partitioning*[5], chemical and biological transformation, and preferential bioaccumulation may change the composition of the PCB mixture over time: the environmentally aged PCB mixture may vary considerably from the original congener composition (US EPA, 1996b and ATSDR, 1995). Altered PCB mixtures have been known to persist in the environment for many years.

PCBs adsorb to organic matter, sediments, and soil. Their affinity to adsorb increases with the chlorine content of the PCBs and the amount of organic matter present. PCBs can volatilize or disperse as aerosols providing an effective means of transport in the environment. Congeners with low chlorine content tend to be more volatile and more water soluble.

The highly chlorinated Aroclors (Aroclor 1248, 1254, and 1260) resist both chemical and biological transformation (i.e., degradation) in the environment. Biological degradation of

[4]The concentration of PCDFs in commercial PCB samples ranged from 0.2 micrograms per gram (µg/g) to 13.6 µg/g (ATSDR, 1993). Eisler (1986) reported PCDFs impurities ranging from 0.8 to 33 milligrams per kilogram (mg/kg) in some domestic and foreign PCB mixtures.

[5]*Partitioning* includes environmental processes by which different fractions of a mixture separate into air, water, sediment, and soil.

highly chlorinated Aroclors to lower chlorinated PCBs can occur under anaerobic conditions[6]. The extent of this dechlorination[7] is limited by the PCB chlorine content and soil/sediment PCB concentrations. Anaerobic bacteria in soil/sediments remove chlorines from low chlorinated PCBs (1 to 4 chlorines) and open the carbon rings through oxidation. PCBs with higher chlorine content are extremely resistant to oxidation and hydrolysis. Photolysis can also slowly break down highly chlorinated PCB congeners.

PCBs bioaccumulate and biomagnify through the food chain because they are highly lipid soluble. The mixture of congeners found in biotic tissue will differ dramatically from the mixture of congeners originally released to the environment because bioaccumulation and biomagnification concentrate PCB congeners of higher chlorine content up through the food chain. This is because different congeners can exhibit different rates of metabolism and elimination in living organisms (Van den Berg, et al., 1998 and Cogliano, 1998).

By altering the congener composition of PCB mixtures, these environmental processes can substantially increase or decrease the toxicity of environmental PCBs mixture (Cogliano, 1998). Therefore, information on these environmental processes along with the results of congener-specific analyses of environmental and biota samples should be used to substantiate modeling of exposure to and health risks resulting from environmental PCBs.

4.0 PCB CLEANUP LEVELS

PCB-contaminated soil/sediments should be remediated to either 1) a default concentration of 1 mg/kg or part per million (**ppm**) *total PCBs* (defined as the sum of congeners, Aroclors or *homologues*[8]), 2) a risk-based generic screening level (see media-specific screening levels in Appendix A of Volume 1) or 3) a *site-specific risk-based PCB concentration level*[9] established through performing a health risk evaluation. Site-specific risk-based PCB concentrations may be calculated from equations presented in *Risk Evaluation*. Once the calculations have been completed for all receptors, the lowest computed risk-based PCB concentration in a medium would represent the PCB remediation goal for that medium. These PCB remediation goals may be refined, if necessary, in the higher-level, site-specific risk assessment.

Table D-1 presents the corrective action cleanup options for the remediation of PCB-contaminated soil/sediments and data quality recommendations regarding the PCB analyses of environmental media samples.

[6]However, certain fungi have been demonstrated to degrade PCBs under aerobic conditions.

[7]Note that dechlorination is not synonymous with detoxification because it may result in the formation of carcinogenic congeners.

[8]A *homologue* is a subcategory of PCBs having an equal number of chlorine substituents. *Substituent* means an atom or group that replaces another atom or group in a molecule. PCB homologues can be quantified using EPA Method 680 or estimated using regression equations such as those found in NOAA, 1993.

[9]A *risk-based PCB concentration level* means the PCB concentration above which some adverse health effects may be produced in human and/or ecological receptors, and below which adverse health effects are unlikely to occur.

Table D-1. PCB Cleanup Options in Soil/Sediment and Data Quality Recommendations[10]

Cleanup Option	Corrective Action Steps		Data Quality Recommendations
Default Option 1	1	Delineate the nature and horizontal and vertical extent of contamination	Estimate total PCBs as the sum of Aroclors or homologues (using a quantitation limit of 50 parts per billion [ppb] or 1 ppb, respectively) in environmental media
	2	Remediate to 1 ppm	
	3	Conduct post-remediation monitoring, as necessary	
Default Option 2	1	Delineate the nature and horizontal and vertical extent of contamination	Estimate total PCBs as the sum of Aroclors or homologues (using a quantitation limit of 50 parts per billion [ppb] or 1 ppb, respectively) in environmental media
	2	Remediate to generic risk-based screening level (See Appendix A of Volume 1))	
	3	Conduct post-remediation monitoring, as necessary	
Site-Specific, Risk-Based	1	Delineate the nature and horizontal and vertical extent of contamination	Estimate total PCBs as the sum of Aroclors or homologues (using a quantitation limit of 50 ppb or 1 ppb, respectively) and/or congener-specific environmental and biota concentrations (using a quantitation limit in the low parts per trillion)
	2	Perform health risk evaluation	
	3	Establish risk-based concentrations for all human and environmental receptors	
	4	Remediate to the lowest risk-based concentration	
	5	Conduct post-remediation monitoring, as necessary	

The following is a listing of potential PCB target analytes[11]. The 12 PCB congeners indicated in boldface italics are those which are recommended for quantitation as potential target analytes when performing a risk-based cleanup. The 16 additional congeners listed in plain text may provide valuable information but are not required for the evaluation of risk. The analyses of all 209 congeners would greatly improve the estimate of total PCB concentrations.

[10]Modified from Valoppi, et al., 1999.

[11]The number in parentheses refers to the identification system used to specify a particular congener.

Table D-2. Potential PCB Target Analytes

2,4′-Dichlorobiphenyl (8)	2,2′,3,4,4′,5′-Hexachlorobiphenyl (138)
2,2′,5-Trichlorobiphenyl (18)	2,2′,4,4′,5,5′-Hexachlorobiphenyl (153)
2,4,4′-Trichlorobiphenyl (28)	***2,3,3′,4,4′,5-Hexachlorobiphenyl (156)***
2,2′,3,5′-Tetrachlorobiphenyl (44)	***2,3,3′,4,4′,5′-Hexachlorobiphenyl (157)***
2,2′,5,5′-Tetrachlorobiphenyl (52)	***2,3′,4,4′,5,5′-Hexachlorobiphenyl (167)***
2,3′,4,4′-Tetrachlorobiphenyl (66)	***3,3′,4,4′,5,5′-Hexachlorobiphenyl (169)***
3,3′,4,4′-Tetrachlorobiphenyl (77)	2,2′,3,3′,4,4′,5-Heptachlorobiphenyl (170)
3,4,4′,5-Tetrachlorobiphenyl (81)	2,2′,3,4,4′,5,5′-Heptachlorobiphenyl (180)
2,2′4,5,5′-Pentachlorobiphenyl (101)	2,2′,3,4′,5,5′,6-Heptachlorobiphenyl (187)
2,3,3′,4,4′-Pentachlorobiphenyl (105)	***2,3,3′,4,4′,5,5′-Heptachlorobiphenyl (189)***
2,3,4,4′,5-Pentachlorobiphenyl (114)	2,2′,3,3′,4,4′,5,6-Octachlorobiphenyl (195)
2,3′,4,4′,5-Pentachlorobiphenyl (118)	2,2′,3,3′,4,4′,5,5′,6-Nonachlorobiphenyl (206)
2′,3,4,4′,5′-Pentachlorobiphenyl (123)	2,2′,3,3′,4,4′,5,5′,6,6′-Decachlorobiphenyl (209)
3,3′,4,4′,5-Pentachlorobiphenyl(126)	
2,2′,3,3′,4,4′-Hexachlorobiphenyl (128)	

The 16 PCB congeners in plain text have been indicated as target analytes by the National Oceanic and Atmospheric Administration based on their toxicity, ubiquitousness in the marine environment, presence in commercial Aroclor mixtures, etc. (NOAA, 1993).

5.0 ANALYTICAL METHODS

Aroclors are often used to characterize PCB exposures; however, the use of Aroclors in estimating the human health or ecological risk can be both imprecise and inappropriate because the PCB mixtures to which humans and other biota may be exposed may be considerably different from the original Aroclor mixtures released to the environment. In addition, traditional analytical methods for Aroclor analyses produce estimates that are prone to errors. Both qualitative and quantitative errors may arise from interpreting gas chromatography (**GC**) data.

GCs configured with electron capture detectors (**ECD**) or electrolytic conductivity detectors (**ELCD**) are particularly prone to error. The GC/ECD and GC/ELCD produce a chromatogram that is compared with the characteristic chromatographic patterns of the different Aroclors (US EPA, 1996a). For environmentally weathered and altered mixtures, an absence of these characteristic patterns can suggest the absence of Aroclors even if some congeners are present in high concentrations. Additionally, and commonly, the presence of interferents may also mask the characteristic response pattern of the Aroclors. The "pattern recognition" technique is inherently subjective, and different analysts may reach different conclusions regarding the presence or absence of Aroclors.

GCs configured with mass spectral detectors (**GC/MS**) allow identification of individual chemical compounds. GC/MS also produces a chromatogram, and additionally includes mass spectral information about the chemical identity of each peak in the chromatogram. Therefore, GC/MS adds a qualitative line of evidence above that included in GC/ECD or GC/ELCD techniques. GC/MS may be subject to interference, misinterpretation, or other problems.

High resolution (**HR**) isotope dilution GC/high resolution MS (**HRGC/HRMS**), while not as common technique as GC-ECD or GC-MS, is a specific GC/MS technique that has proven reliable for PCB analysis. In HRGC/HRMS exhaustive sample clean-up techniques are employed, and isotopic tracers are used to support identification.

Therefore, the HWB recommends the use of HRGC/HRMS analyses in evaluating health risks to humans and the environment. If HRGC/HRMS methods are not employed, then site specific data must be used to demonstrate that the methods employed are appropriate to the site, or HRGC/HRMS confirmation must be integrated into the analytical plan, for instance on a one in 20 sample basis, or a for a minimum number of samples, or as otherwise agreed. Both detections and non-detections should be confirmed.

Results of GC techniques may be expressed as Aroclors, congeners, homologues, or as total PCBs in units of weight/weight [mg/kg, µg/kg, nanogram per kilogram (ng/kg)] or weight/volume [µg/L or pictogram per liter (pg/L)]. It is necessary to specify the reporting requirements prior to analysis and negotiate the analytical list and reporting limits. Results must be reported on a dry weight basis for soil, sediment and waste samples (excluding liquids).

In addition to the traditional GC analysis, a number of biological and immunological assays are now available, as well as field GC. These may be suited for use as screening methods to guide day-to-day remediation efforts but are not suited to evaluating health risks to humans and the environment as stand-alone methodologies.

Table D-3. Analytical Methods for PCBs

Method	Technology	Report As[1]	Approximate Detection Limits	Comments
SW-846 8082A	GC/ECD or GC/ELCD	Aroclors Congeners	>0.5µg/kg	Must supply site-specific performance data or use HRGC/HRMS confirmation
SW-8270D	GC/MS	Aroclors	>1000 µg/kg[2]	Detection limits may not support project data quality objectives
SW-846 8275A	GC/MS	Congeners	200 µg/kg	
Method 1668B	HRGC/HRMS	Congeners	<1µg/kg, often in the ng/kg range[2]	Use this method for confirmation

NOTES:
[1]Reporting types have been limited to those mentioned in the subject methods. Laboratories may offer additional reporting modalities, such as homologues and total PCBs.
[2]Detection Limits not specified in the method. Various sample preparation options and matrix effects may affect results

6.0 STORM WATER RUNOFF MONITORING RECOMMENDATIONS

The potential for transport to human or ecological receptors (including ground and surface water) should be evaluated for all corrective action sites impacted or suspected of being impacted by PCBs. PCB concentrations in storm water runoff resulting from contaminated soil/sediments should be monitored **and** the soils remediated to ensure that there is no release or runoff from the

Solid Waste Management Unit (**SWMU**) or Area of Concern (**AOC**) which results in a total PCB concentration in excess of the Clean Water Act (**CWA**)-recommended freshwater aquatic life chronic criterion of 0.014 µg/L[12] (unfiltered water) to a *water of the State*.[13] Likewise, concentrations of PCB-contaminated stream bottom, lake or reservoir deposits should not result in total PCB concentrations in unfiltered water which exceeds the CWA-recommended freshwater aquatic life chronic criterion of 0.014 µg/L.

The evaluation of a site's PCB concentrations and erosion potential will aid in determining and prioritizing the corrective actions and best management practices (**BMPs**) necessary to protect surface water quality. Each facility should develop a method for evaluating the erosion potential[14] and present the methodology to the NMED HWB for approval prior to implementation. This evaluation should be conducted on all known or suspected PCB sites. All PCB sites with elevated erosion potentials should implement BMPs to reduce transport of PCB-contaminated sediments and soils. BMP effectiveness should be evaluated and monitored regularly through a formalized inspection and maintenance program. BMPs should be implemented as interim actions or stabilization measures which are consistent with a final remedy and should not be misconstrued as a final remedy.

NMED's HWB believes that controlling the total suspended solids (**TSS**) load of storm water runoff may effectively control PCB migration in surface water because PCBs are hydrophobic, tend to adsorb to soil and organic particles, and are transported in suspended sediments during storm runoff events. Therefore, the TSS should be monitored to aid in predicting and, therefore, potentially controlling the transport of PCBs into *watercourses*[15].

Storm water samples should be collected from storm water events which are greater than 0.1 inches in magnitude (US EPA, 1992). Grab samples should be collected within the first 30 minutes or as soon as practical, but not more than 1 hour after runoff discharge begins. A sufficient quantity of runoff should be collected (i.e., 5 liters) because additional analyses for PCBs may be required based upon the TSS analytical results. The runoff samples should be analyzed for TSS using Method 2540D of the most recent edition of the *Standard Methods for the Examination of Water and* Wastewater.

Grab samples should be used for monitoring. Composite samples may **not** be used for monitoring; however, flow-weighted composite samples may be used in the development and validation of storm water contaminant transport modeling.

The following bullets describe recommended trigger levels and actions based on the analytical results of TSS analyses:

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[12]This concentration is the Clean Water Act §304(a) recommended chronic criterion for aquatic life (https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table).

[13]*Water(s) of the State* means all interstate and intrastate water including, natural ponds and lakes, playa lakes, reservoirs, perennial streams and their tributaries, intermittent streams, sloughs, prairie potholes and wetlands (Title 20 New Mexico Annotated Code Chapter 6.1).

[14]NMED HWB recommends the approach to evaluating erosion potential presented in the *Matrix Approach to Contaminant Transport Potential* (Mays and Veenis, 1998).

[15]*Watercourse* means any river, creek, arroyo, canyon, draw, or wash, or any other channel having definite banks and beds with visible evidence of the occasional flow of water (Title 20 New Mexico Annotated Code Chapter 6.1).

- If TSS is less than 100 mg/L, no action is required.
- If TSS is greater than 100 mg/L, but less than 1,000 mg/L, then the effectiveness of existing BMPs should be evaluated and repaired as necessary, and additional BMPs may need to be implemented to reduce TSS loading.
- If the TSS is greater than 1,000 mg/L, then the remaining portion of the sample should be centrifuged and the solids analyzed for PCBs using EPA SW-846 Method 8082 (US EPA, 2007), EPA Method 680, or draft EPA Method 1668 (Alford-Stevens, et al., 1985 and US EPA, 1996a).

7.0 RISK EVALUATION

The risk to human health and the environment must be evaluated for all corrective action *solid waste management units/areas of concern*[16] (**SWMU/AOCs**) impacted or suspected of being impacted by PCBs and having a potential for transport to a human or ecological receptor. The risk posed by PCBs at these SWMU/AOCs may be modeled (based on adequate available data) and should be monitored to ensure an acceptable level of risk[17] (see *Storm Water Runoff Monitoring Recommendations)*.

As discussed in *Environmental Processes*, the congener composition of environmentally aged PCBs can dramatically differ from the original Aroclor mixture released to the environment. Consequently, environmental processes can affect both exposure to, and toxicity of, environmental PCBs. Therefore, the approach to evaluating health risks from environmental PCBs differs depending upon whether the PCB congener- or Aroclor-specific (or homologue-specific) data are available for the environmental media (see also *PCB Cleanup Levels*).

PCB congeners with chlorine atoms in positions 2 and 6 (ortho) are generally more readily metabolized, while those with chlorines in positions 4 and 4' (para) or positions 3, 4 or 3, 4, 5 on one or both rings tend to be more toxic and are retained mainly in fatty tissues (Eisler, 1986). Persistent congeners may retain biological activity long after the exposure. The most toxic PCB congeners can assume a conformation, generally similar to that of 2, 3, 7, 8-tetrachloro-dibenzo-dioxin (**TCDD**) and are approximate stereo analogs of this compound (Hoffman, et al., 1996).

These dioxin-like congeners share a common mechanism of toxicity involving binding to the aryl hydrocarbon receptor; the same mechanism of action is believed to induce the toxicity of PCDDs and PCDFs. These congeners were assigned toxicity equivalency factors (**TEFs**) expressed as a fraction of the toxicity of 2,3,7,8-TCDD. Therefore, when PCB congener-specific analytical data are available, risk evaluation of human and ecological health should consider both dioxin-like and other adverse health effects. Two sections within this document (*Human Health, Carcinogenic Effects, Dioxin-like Toxicity Approach* and *Ecological Health, Dioxin-like PCBs*) provide guidance for applying these TEFs where congener-specific analyses are available. If only Aroclor/homologue concentrations are available for a site, total PCB concentrations

[16]*SWMU* means "any discernable unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at a facility at which solid wastes have been routinely and systematically released." *AOC* "...refers to releases which warrant investigation or remediation under the authorities discussed above, regardless of whether they are associated with a specific SWMU..."

[17]A risk or hazard is considered *acceptable* if an estimated risk/hazard is below pre-established target risk and/or hazard levels.

reported as the sum of Aroclor/homologue concentrations should be used to estimate the risk to human health and the environment.

If a health risk evaluation is based on total PCB concentrations (estimated as the sum of Aroclors or PCB homologues) and the individual congeners comprising the PCB mixtures cannot be identified, the uncertainty and potential bias in the resulting risk estimates should be described in the risk assessment report. For example, if total PCB concentrations have been estimated based on Aroclor analyses, conservative assumptions should be made about the mixture composition and toxicity: the assumption that congeners with greater than four chlorines per PCB molecule comprise greater than 0.5% of total PCBs present in a given abiotic medium at the site triggers the selection of the highest cancer slope factor from Table D-3. Whereas total PCB concentrations estimated based on the results of PCB homologue analyses may allow for a refinement of these conservative assumptions. More detailed information on an approach to evaluating the health risk from environmental PCBs and PCB data requirements can be found in US EPA (1996b); Van den Berg, et al. (1998); Cogliano (1998); Giesy and Kannan (1998) and Valoppi, et al. (1999).

7.1 Human Health

Since PCBs may cause both carcinogenic and noncarcinogenic adverse human health effects, separate risk assessments must be performed for each of these health effects.

7.1.1 7.1.1 Carcinogenic Effects

The evaluation of carcinogenic risk from exposure to PCB mixtures (i.e., represented by total PCBs or PCB congeners) should follow the slope factor approach described in *PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures* (US EPA, 1996b) and as outlined below. This approach distinguishes among toxic potencies of different PCB mixtures by utilizing information regarding environmental processes. In the absence of PCB congener- or homologue-specific analyses (i.e., if total PCB concentrations were estimated based on Aroclor analyses), this approach requires conservative assumptions about the risk and persistence of PCB mixtures at the site.

If congener-specific concentrations are available and congener analyses indicate that congeners with more than 4 (four) chlorines comprise greater that 0.5 percent of total PCBs in a given medium, the slope factor approach should be supplemented by the analysis of dioxin toxicity equivalency quotient (**TEQ**). Risk from *dioxin-like congeners*[18] should be added to the risk estimated for the rest of the PCB mixture which does not exhibit dioxin-like toxicity.

If other dioxin-like compounds (i.e., PCDDs and/or PCDFs) are present at a site in addition to PCBs, TEQs for dioxin-like PCBs should be added to TEQs calculated for those other dioxin-like compounds to yield a total TEQ. A slope factor for 2,3,7,8-TCDD should be applied to this total TEQ. Under these circumstances, the concentrations of dioxin-like PCBs should be subtracted from the total PCB concentration to avoid overestimating risks from dioxin-like PCBs by evaluating them twice.

[18]*Dioxin-like congeners* of PCBs are those with dioxin-like health effects and are evaluated using dioxin TEQs (Van den Berg, et al., 1998). A complete listing of PCB congeners can be found at http:\\www.epa.gov/grtlakes/toxteam/pcbid/table.htm (US EPA's Great Lakes website).

7.1.1.1 Slope Factor Approach

Site-specific carcinogenic risk evaluations should be performed using PCB cancer potency or slope factors specific to the exposure scenarios and pathways at a particular site. Table D-4 provides the criteria for using these slope factors (categorized into high, medium, and low levels of risk and PCB persistence) that address a variety of exposure scenarios and the toxicity of PCB mixtures in the environment. A review of recent research on PCB toxicity that formed the basis for the derivation of these slope factors and a discussion of uncertainties surrounding toxicity information can be found in US EPA (1996b, 2016) and Cogliano (1998).

The slope factors in Table D-4 represent the upper-bound slopes that are recommended for evaluating human health risk from carcinogenic effects of PCBs. Both the upper-bound and central-estimate slopes are available from the US EPA's Integrated Risk Information System (**IRIS**). The central-estimate slopes can be used to support the analysis of uncertainties inherent in available toxicity information on PCBs.

Table D-4. PCB Cancer Slope Factor Values by Level of Risk and Persistence[19]

CRITERIA FOR USE	LEVEL OF RISK AND PERSISTENCE	PCB CANCER SLOPE FACTOR VALUES[20] [risk per mg/kg-day]
Food chain exposure	High	2.0E+00
Sediment/soil ingestion		
Dust/aerosol inhalation		
Dermal exposure (if an absorption factor has been applied)		
Presence of dioxin-like, tumor-promoting, or persistent congeners		
Early-life (less than 6 years old) exposure by all pathways and to all mixtures		
Congeners with greater than four chlorines per PCB molecule comprise greater than 0.5% of the total PCBs present		
Congeners with greater than four chlorines per PCB molecule comprise less than 0.5% of the total PCBs present (all pathways except soil ingestion by adults)		
Ingestion of water-soluble (less chlorinated) congeners	Medium	4.0E-01
Inhalation of evaporated (less chlorinated) congeners		
Dermal exposure (if no absorption factor has been applied)		
Congeners with greater than four chlorines per PCB molecule comprise less than 0.5% of the total PCBs present (soil ingestion by adults only)	Low	7.0E-02

The cancer slope factors in Table D-4 characterize the toxic potency of different environmental mixtures of PCBs. Information on potential exposure pathways and PCB mixture composition at a given site guides in the selection of the appropriate cancer slope factors for risk assessment.

The highest slope factor in Table D-4 (2.0E+00 per mg/kg-day) corresponds to the high risk and persistence of environmental PCB mixtures and, as such, should be selected for pathways (including food chain exposures, ingestion of soil and sediment, inhalation of dust or aerosol, exposure to dioxin-like, tumor-promoting or persistent congeners, and early-life exposure) where environmental processes act to increase risk.

[19]Modified from Cogliano, 1998 and US EPA, 1996b and 1998c.

[20]See IRIS (US EPA, 2016).

A lower slope factor (4.0E-01 per mg/kg-day) corresponds to the low risk and persistence of environmental PCB mixtures and is appropriate for exposure pathways (such as ingestion of water-soluble congeners and inhalation of evaporated congeners) where environmental processes act to decrease risk.

Finally, the lowest slope factor in Table D-4 (7.0E-02 per mg/kg-day) corresponds to the lowest risk and persistence of environmental PCB mixtures and should be selected for soil ingestion by adults when congener or homologue analyses confirm that congeners with greater than four chlorine atoms per PCB molecule comprise less than 0.5% of the total PCBs present at the site.

Once the appropriate slope factor has been selected, it is multiplied by a lifetime average daily dose (**LADD**) to estimate the risk of cancer (see US EPA, 1996b for sample risk calculations). Because the use of Aroclors to characterize PCB exposures can be both imprecise and inappropriate, total PCBs or congener analyses should be used in the following LADD calculation:

$$\mathbf{LADD = (C_T \times IR \times ED \times EF) / (BW \times AT)} \qquad \textit{Equation D-1}$$

Where:

LADD =	Lifetime average daily dose (mg/kg-day)
C_T =	Total PCBs or total non-dioxin-like congener concentration in a medium (mg/L [water], mg/kg [soil], or milligram per cubic meter (mg/m^3) [air])
IR =	Intake rate (L/day [water], mg/day [soil], or mg/m^3 [air])
ED =	Exposure duration (years)
EF=	Exposure frequency (days/year)
BW =	Average body weight of the receptor over the exposure period (kg)
AT=	Averaging time - the period over which exposure is averaged (days)[21]

The cancer slope factors and recommended Aroclor fate and transport properties (Table D-5), should be used to evaluate the carcinogenic risk posed by PCB mixtures or PCB congeners which do not exhibit a dioxin-like toxicity.

[21]For carcinogens, the averaging time is 25,550 days based on a lifetime exposure of 70 years.

Table D-5. Cancer Slope Factors and Fate & Transport Properties for PCBs

	CRITERIA: Congeners with equal to or greater than four (4) chlorines comprise . . .	CARCINOGENIC EFFECTS	
		Dioxin-like PCBs	Other PCB Congeners[22]
CANCER SLOPE FACTORS[23] $(mg/kg\text{-}day)^{-1}$	. . . **greater than 0.5%** of the total PCBs present	1.3E+05[24]	2.0E+00
	. . . **less than 0.5%** of the total PCBs present	NA[25]	7.0E-02
FATE & TRANSPORT PROPERTIES	. . . **greater than 0.5%** of the total PCBs present	Aroclor 1254	Aroclor 1254
	. . . **less than 0.5%** of the total PCBs present	Aroclor 1016	Aroclor 1016

For example, if a PCB mixture contains 45% congeners with greater than four chlorines, the cancer slope factor for 2,3,7,8-TCDD and the fate and transport properties of Aroclor 1254 would be used.

If the following special exposure conditions exist, a slope factor of 4.0E-01 may be applied to PCBs which do not exhibit dioxin-like toxicity: ingestion of water-soluble congeners, inhalation of evaporated congeners or dermal exposure (with no applied absorption factor).

7.1.1.2 Dioxin-like Toxicity Approach

Dioxin-like PCBs are some of the moderately chlorinated PCB congeners (see Table D-5) which have been demonstrated to produce dioxin-like effects[26] in humans. The dioxin-like toxicity approach should be implemented **only** when congener-specific concentrations are available for environmental media at a site. In this approach, individual dioxin-like PCB congener concentrations are multiplied by TEFs that represent the potency of a given congener relative to 2,3,7 8-TCDD (see Table 2-2 in Volume I).

Table 2-2 of Volume I lists the TEF values derived for dioxin-like PCB congeners. Using TEF values in the risk evaluation allows for the estimation of a combined risk resulting from an exposure to a mixture of dioxin-like PCB congeners (assuming that the risks are additive).

[22]*Other PCB congeners* mean those congeners which do not exhibit dioxin-like toxicity.

[23]PCB cancer slope factors can be found in IRIS (US EPA, 2016).

[24]US EPA, 2016

[25]*NA* means not applicable. Do not evaluate dioxin-like PCBs if they comprise less than 0.5% of the total PCBs present; evaluate the other PCB congeners.

[26]Dioxin-like congeners can react with the aryl hydrocarbon receptor, the toxicity mechanism that is believed to initiate the adverse effects of PCDDs and PCDFs.

The carcinogenic risk resulting from exposure to dioxin-like PCBs should be estimated by calculating the TEQ. The TEQ is the sum of each congener-specific concentration in the medium multiplied by its corresponding congener-specific TEF value. Multiplying the congener-specific medium concentration by the corresponding congener-specific TEF value provides a relative (i.e., "toxicity-weighted") measure of the dioxin concentration within a medium.

The TEQ for dioxin-like PCBs should be calculated as indicated in the following equation:

$$\mathbf{TEQ = \Sigma\ (C_{mi} \times TEF_i)} \qquad \textit{Equation D-2}$$

Where:

TEQ	=	Toxicity equivalency quotient (mg/L [water] or mg/kg [soil or sediment])
C_{mi}	=	Concentration of *i*th congener in medium (mg/L [water] or mg/kg [soil or sediment])
TEF_i	=	Toxicity equivalency factor for *i*th congener (unitless)

Once the dioxin TEQ has been determined, the LADD should be calculated using the following equation:

$$\mathbf{LADD = (TEQ \times IR \times ED \times EF) / (BW \times AT)} \qquad \textit{Equation D-3}$$

Where:

LADD	=	Lifetime average daily dose (mg/kg-day)
TEQ	=	Toxicity equivalency quotient (mg/L [water], mg/kg [soil], or mg/m^3 [air])
IR	=	Intake rate (L/day [water], mg/day [soil], or mg/m^3 [air])
ED	=	Exposure duration (years)
EF	=	Exposure frequency (days/year)
BW	=	Average body weight of the receptor over the exposure period (kg)
AT	=	Averaging time - the period over which exposure is averaged (days)

The following equation can be used to estimate carcinogenic risk from dioxin-like PCBs:

$$\mathbf{Cancer\ Risk = LADD \times CSF_{TCDD}} \qquad \textit{Equation D-4}$$

Where:

LADD	=Lifetime average daily dose (mg/kg-day)
CSF_{TCDD}	=Cancer slope factor for 2,3,7,8-TCDD[27]

[27]The cancer slope factor for 2,3,7,8-TCDD should be obtained from the most recent IRIS (US EPA, 2016). The current oral cancer slope factor for 2,3,7,8-TCDD of 1.3E+05 $(mg/kg\text{-}day)^{-1}$ is based on the administered dose from a 105-week dietary rat study and was adopted for inhalation exposure (US EPA, 2016).

7.1.2 7.1.2 Noncarcinogenic Effects

For Aroclors having reference doses (**RfDs**) specified in IRIS (e.g., Aroclor 1254, 1016, etc.), the noncarcinogenic risk should also be evaluated. The evaluation of noncarcinogenic risk should follow the approach typical for other non-PCB chemicals. However, fate and transport properties of the recommended Aroclor (see Table D-6) should be used to evaluate the risk posed.

Table D-6. Toxicological and Fate & Transport Properties for PCBs With Human Health Noncarcinogenic Effects and Ecological Health Non-Dioxin-Like Effects

CRITERIA: Congeners with equal to or greater than four (4) chlorines comprise . . .	**NONCARCINOGENIC EFFECTS AND FATE AND TRANSPORT PROPERTIES**
. . . **greater than 0.5%** of the total PCBs present	Aroclor 1254
. . . **less than 0.5%** of the total PCBs present	Aroclor 1016

The RfD derived for Aroclor 1254 should typically be used when conducting a risk assessment. The RfD derived for Aroclor 1016 can be used when at least 99.5% of the mass of the PCB mixture has fewer than four (4) chlorine atoms per molecule as determined by a chromatography/spectroscopy analytical method. Using Table D-6, determine which Aroclor most accurately represents the PCB mixture of concern. Use the RfD and fate and transport properties of this Aroclor as a surrogate to evaluate the noncarcinogenic effects of the PCB mixture.

7.2 Ecological Health

Since PCBs adversely impact both community- and class-specific guild measurement receptors, risks must be estimated for each receptor within both groups. Plants and invertebrates should be evaluated as community measurement receptors (see *Volume II*).

When congener-specific concentrations are available, risk from exposure to dioxin-like PCBs should be estimated separately and added to the risk estimated for the remainder of the PCB mixture which does not exhibit dioxin-like toxicity. The resulting risk is likely to be overestimated if toxicity data from total PCBs is applied to those congeners which do not exhibit dioxin-like toxicity. This overestimation of risk should be addressed within the uncertainty analysis of the risk assessment report.

In the absence of PCB congener-specific data, total PCB concentrations, reported as the sum of Aroclor or homologue concentrations, should be used to estimate receptor exposure to PCBs and the toxicity value of the most toxic Aroclor present should be used in the site-specific ecological risk assessment.

7.2.1 7.2.1 Dioxin-like PCBs

Ecological risks to community- and class-specific guild measurement receptors from dioxin-like PCBs should be estimated by calculating a TEQ and then dividing it by the toxicity value for 2,3,7,8-TCDD (which is assumed to be the most toxic dioxin).

If in addition to PCBs, other dioxin-like compounds (i.e., PCDDs and/or PCDFs) are present at a site, TEQs for dioxin-like PCBs should be added to the TEQs calculated for those other dioxin-like compounds to yield a total TEQ. The 2,3,7,8-TCDD toxicity value should be applied to this total TEQ. For this evaluation, the concentrations of dioxin-like PCBs should be subtracted from the total PCB concentrations to avoid overestimating risks from dioxin-like PCBs by evaluating them twice.

The TEF values listed in Table 2-1 of Volume I and in Table D-7 (Van de Berg, *et al*., 1998) below should be used in the TEQ calculation to convert the exposure media concentration of individual congeners to a relative measure of concentration within a medium.

Table D-7. Fish Toxicity Equivalency Factor Values for Dioxin-Like PCBs[28]

CONGENER	FISH TOXICITY EQUIVALENCY FACTOR VALUES[29]
3,3′,4,4′-Tetrachlorobiphenyl (77)[11]	0.0001
3,4,4′,5-Tetrachlorobiphenyl (81)	0.0005
2,3,3′,4,4′-Pentachlorobiphenyl (105)	<0.000005[30]
2,3,4,4′,5-Pentachlorobiphenyl (114)	<0.000005
2,3′,4,4′,5-Pentachlorobiphenyl (118)	<0.000005
2′,3,4,4′,5′-Pentachlorobiphenyl (123)	<0.000005
3,3′,4,4′,5-Pentachlorobiphenyl (126)	0.005
2,3,3′,4,4′,5-Hexachlorobiphenyl (156)	<0.000005
2,3,3′,4,4′,5′-Hexachlorobiphenyl (157)	<0.000005
2,3′,4,4′,5,5′-Hexachlorobiphenyl (167)	<0.000005
3,3′,4,4′,5,5′-Hexachlorobiphenyl (169)	<0.000005
2,3,3′,4,4′,5,5′-Heptachlorobiphenyl (189)	<0.000005

Because congener-specific fate and transport data are not available for each of the dioxin-like PCBs listed in Table 2-1 of Volume I and Table D-7, the fate and transport properties of Aroclor 1254 should be used in exposure modeling.

7.2.1.1 Exposure Assessment for Community Measurement Receptors

To evaluate the exposure of water, sediment and soil communities to dioxin-like PCBs, a media-specific TEQ should be calculated. The TEQ is the sum of each congener-specific concentration (in the respective media to which the community is exposed) multiplied by its corresponding congener-specific TEF value derived for fish (Table D-7).

The TEQ for community measurement receptors exposed to dioxin-like PCBs should be calculated as indicated in the following equation:

$$\mathbf{TEQ = \Sigma (C_{mi} \times TEF_i)} \qquad \textit{Equation D-5}$$

Where:

TEQ = Toxicity equivalency quotient (µg/L [water] or µg/kg [dry weight soil or sediment])

[28]Modified from the *Report from the Workshop on the Application of 2,3,7,8-TCDD Toxicity Equivalency Factors to Fish and Wildlife* (US EPA, 1998b).

[29]The surrogate TEF values for fish are presented because invertebrate-specific TEF values have not yet been developed.

[30]For all fish TEFs of "<0.000005," use the value of 0.000005 as a conservative estimate.

C_{mi} = Concentration of *i*th congener in abiotic media (µg/L [water] or µg/kg [dry weight soil or sediment])
TEF_i = Toxicity equivalency factor (fish) for *i*th congener (unitless) (Table D-7)

Risk to the water, sediment or soil community is subsequently evaluated by comparing the media-specific TEQ to the media-specific toxicity value for 2,3,7,8-TCDD:

$$\textbf{Risk} = \textbf{TEQ} / \textbf{TRV}_{TCDD} \qquad \textit{Equation D-6}$$

where:

TEQ = Toxicity equivalency quotient (µg/L [water] or µg/kg [dry weight soil or sediment])
TRV_{TCDD} = Toxicity reference value for 2,3,7,8-TCDD (µg/L [water] or µg/kg [dry weight soil or sediment])

7.2.1.2 Exposure Assessment for Class-Specific Guild Measurement Receptors

To evaluate the exposure of class-specific guild measurement receptors to dioxin-like PCBs, congener-specific daily doses of food items (i.e., abiotic media, plants, animals, etc.) ingested by a measurement receptor (**DD_i**) should be converted to a TEQ-based daily dose (**DD_{TEQ}**). This DD_{TEQ} can subsequently be compared to the 2,3,7,8-TCDD toxicity values for an evaluation of the risk posed to class-specific guild measurement receptors.

The DD_{TEQ} for each measurement receptor should be calculated as shown in the following equation:

$$\textbf{DD}_{TEQ} = \Sigma\, \textbf{DD}_i \times \textbf{TEF}_{MR} \qquad \textit{Equation D-7}$$

Where:

DD_{TEQ} = Daily dose of PCB TEQ (µg/kg fresh body weight-day)
DD_i = Daily dose of *i*th congener (µg/kg fresh body weight-day)
TEF_{MR} = Toxicity equivalency factor (specific to measurement receptor) (unitless) (Table D-8)

Risk to the class-specific guild being evaluated can be estimated by dividing the DD_{TEQ} by the toxicity reference value for 2,3,7,8-TCDD:

$$\textbf{Risk} = \textbf{TEQ} / \textbf{TRV}_{TCDD} \qquad \textit{Equation D-8}$$

Where:

DD_{TEQ} = Daily dose of PCB TEQ (µg/kg fresh body weight-day)
TRV_{TCDD} = Toxicity reference value for 2,3,7,8-TCDD (µg/kg fresh body weight-day)

[31]The congener-specific daily doses of food items ingested by a measurement receptor should be calculated in accordance with the most current EPA and/or State guidance.

7.2.2 7.2.2 Other PCB Congeners

In addition to the dioxin-like PCB congeners, the remaining PCBs should be evaluated like other bioaccumulating organic contaminants by assessing ecological risks to community- and class-specific guild measurement receptors. The fate and transport properties of Aroclor 1254[32] should be used in the exposure modeling when evaluating the risk from PCB mixtures containing congeners with equal to or greater than 4 chlorines in quantities **greater** than 0.5% of the total PCBs. And the fate and transport properties of Aroclor 1016[33] should be used in the exposure modeling when evaluating risks from PCB mixtures containing **less** than 0.5 % of PCB congeners with more than 4 chlorines (see Table D-6).

8.0 CONCLUSION

PCBs, which are a class of organic compounds that are persistent in the environment, are toxic to both humans and biota. PCBs may in certain instances become contaminated with more toxic PCDFs and PCDDs. Therefore, the potential presence of these compounds should also be evaluated and possibly investigated.

Based on federal and state regulations and standards, the NMED recommends that PCB-contaminated sediment/soils be remediated to either 1 mg/kg total PCBs or the most stringent of the calculated health risk-based concentrations in order to adequately protect human health and the environment.

Unless soil/sediments are remediated to 1 mg/kg total PCBs, the risk posed by PCBs to human health and the environment should be evaluated using a risk-based approach. All corrective action SWMU/AOCs impacted or suspected of being impacted by PCBs and having a potential for transport to a human or ecological receptor should be evaluated and monitored, as necessary, to protect human health and the environment.

PCB concentrations in soil/sediments should also be protective of both surface water and ground water resources; PCB concentrations in surface water should not exceed 0.014 µg/L and PCB concentrations in ground water cannot exceed 0.5 µg/L (drinking water) or 0.5 µg/L in ground water with 10,000 mg/L or less total dissolved solids).

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[32]Approximately 77% of Aroclor 1254 is composed of PCB congeners with more than 4 chlorines.

[33]Approximately 99% of Aroclor 1016 is comprised of PCB congeners with 4 or less chlorines.

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APPENDIX E

RECOMMENDATIONS FOR ADDRESSING PERFLUOROHEXANE SULFONIC ACID (PFHxS) IN NEW MEXICO

RECOMMENDATIONS FOR ADDRESSING PERFLUOROHEXANE SULFONIC ACID (PFHxS) IN NEW MEXICO

CAS # 355-46-4
Molecular Weight: 400.1
Molecular Formula: $C_6HF_{13}O_3S$

INTRODUCTION

Perfluoroalkyls are a class of anthropogenic chemicals collectively referred to as per- and poly-fluoroalkylated substances (PFAS). There are a large number of perfluoroalkyl compounds; the ones of current interest are perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorohexane sulfonate (PFHxS). These chemicals (and other PFAS) repel oil, grease, and water and have been used in surface protection products such as carpet and clothing treatments, coating for paper and cardboard packaging, and fire-fighting foams.

Companies have stopped production of some perfluoroalkyls or have begun changing manufacturing practices to reduce releases and the amounts of these chemicals in their products. Numerous studies have examined the possible relationship between levels of PFAS in blood and adverse health effects in workers, highly exposed residents, and the general population. Although statistically significant associations have been found, to date these studies have not established causality. However, it does appear that perfluoroalkyl exposure can be linked to several health outcomes in humans (e.g., increases in serum lipids, pregnancy-induced hypertension and/or pre-eclampsia, thyroid disease). Specific to PFHxS, along with PFOA and PFOS and other PFAS, a decrease in antibody response to vaccines has been observed (Grandjean et al.2012).

In animals, liver toxicity and developmental toxicity have been observed as a result of exposure to PFHxS. However, there are significant differences in the toxicokinetics and mode of action of perfluoroalkyls between humans and experimental animals. Many of the observed effects in animals result through the activation of peroxisome proliferator-activated receptor α (PPAR-α). Humans are much less responsive to PPAR-α than rodents, for example. Thus, humans may not be as susceptible to these types of effects.

Studies in animals suggest that many perfluoroalkyls (including PFOA and PFOS) are almost completely absorbed from the gastrointestinal tract. Limited data indicate PFAS are absorbed from the respiratory tract. PFAS do not appear to metabolize or undergo chemical reactions in the body and are primarily excreted in the urine. There are differences in the elimination half-lives across perfluoroalkyl compounds; however, they tend to exhibit half-lives of the same order of magnitude. The estimated elimination half-lives in humans are 4.7-15.5 years for PFHxS compared to 2.1-8.5 years for PFOA and 3.1-7.4 years for PFOS. Much shorter half-lives have been estimated in experimental animals.

As noted by Bräunig et al and Filipovic et al, PFHxS are found in soil, water and a variety of biota in the vicinity of fire-fighting training areas following the historical use of PFHxS-containing foams, showing that it is persistent and does not undergo any abiotic or biotic

degradation under normal environmental conditions. UNEP/POPS/POPRC.13/4 also showed that PFHxS is persistent in the environment as demonstrated by its frequent detection in biota and the environment, including in the Arctic.

Based on the work described in UNEP/POPS/POPRC.13/4, PFHxS was found to meet the criteria on persistence, bioaccumulation, long-range environmental transport, and adverse effects; thus, it has been listed in Annexes A, B, and C of the Stockholm Convention on Persistent Organic Pollutants. In turn, Sweden proposed that the European Union identify perfluorohexane-1-sulphonic acid and its salts as substances of high concern due to their persistence and bioaccumulation properties.

In June 2017, the European Chemical Agency (ECHA) identified PFHxS as very persistent and very bioaccumulative. ECHA's evaluation concluded that based on the knowledge of the stability of the C-F bond and the structural similarities with PFOS and PFOA, PFHxS is expected to undergo extremely limited degradation in the environment and thus fulfil the persistent and very persistent criteria in Annex XIII of the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation. The work is described in *Agreement of the Member State Committee on the Identification of Perfluorohexane-1-sulfonic acid and its Salts as Substances of Very High Concern*. In addition, the ECHA used a weight-of-evidence approach to determine that PFHxS and its salts met the criteria for very persistent, very bioaccumulative (vPvB) substances according to Article 57(e) of REACH.

In June 2018, the Agency for Toxic Substances and Disease registry (ATSDR) released *Toxicological Profile for Perfluoroalkyls Draft for Public Comment*, a revision of the draft Toxicological Profile for Perfluoroalkyls prepared in 2013. The revised profile includes a Minimum Risk Level (MRL) for intermediate-duration PFHxS oral exposures of 2×10^{-5} milligrams per kilogram per day [mg/(kg·day)].

NATURE OF EXPOSURES TO PFHxS

ATSDR's *ToxGuide™ for Perfluoroalkyls* states that PFAS appear to be ubiquitous in human blood based on the widespread detection of these substances in human serum samples. Geometric mean serum levels of PFOA, PFOS, and PFHxS in the U.S. population (≥12 years of age) were 1.94, 4.99, and 1.35 nanograms per milliliter (ng/mL), respectively.

Potentially high exposures to perfluoroalkyls can occur in the following population categories: perfluoroalkyl production and manufacturing workers, communities located near fluorochemical facilities, and individuals with prolonged use of perfluoroalkyl-containing products.

PFOA, PFOS, PFHxS, and other PFAS, have been detected in the municipal drinking water and private wells of some communities located near fluorochemical facilities. ATSDR's toxicological profile for perfluoroalkyls indicates that a facility in Decatur, AL produced geometric mean serum PFOA, PFOS, and PFHxS levels of 910, 1,130, and 180 ng/mL, respectively, in community members. A follow up study showed residents who used a nearby public water supply had significantly higher geometric mean serum levels of two substances

(PFOA and PFHxS) as compared to the geometric mean for a similar demographic in the control group.

As described in Moody et al, elevated levels of PFOA, PFOS, and PFHxS, measured in groundwater near fire training areas are attributed to the use of these substances in aqueous firefighting foams. The concentrations of these three perfluoroalkyls in groundwater near a military fire-training site in Michigan were 8–105, 4.0–110, and 9–120 µg/L, respectively.

AVAILABLE REGULATORY CRITERIA

In the May 2016 drinking water advisories for PFOS and PFOA, the United States Environmental Protection Agency (USEPA) calculated a lifetime health advisory value of 0.07 µg/l for each chemical. Because the critical effect for PFOS and PFOA was a developmental endpoint that could result from a short-term exposure during a critical period of development, USEPA determined that the lifetime health advisory values are applicable to both short-term and chronic risk assessment scenarios. Thus, the calculated lifetime health advisory values of 0.07 µg/L also apply to short-term exposure scenarios (i.e., weeks to months) to PFOS and PFOA in drinking water, including during pregnancy and lactation.

USEPA recognized the health advisory values for PFOS and PFOA are based on similar developmental effects and are numerically identical. Thus, USEPA recommends that when the two chemicals are encountered at the same time and location in a drinking water source, a conservative and health protective approach to compare the sum of the concentrations of PFOS and PFOA to an HA of 0.07 µg/L.

Table 1. Select State Drinking Water Levels for PFOA, PFOS, and PFHxS
(ppb or µg/L)

STATE	TYPE of VALUE	PFOA	PFOS	PFHxS
New Mexico	For PFOA and PFOS, federal health advisories for tap water. For PFHxS, conversion of ATSDR MSL to drinking water concentration	0.07	0.07	0.04
Maine	Maximum exposure guideline for Drinking water	0.07[a]	0.07[a]	ND
Michigan	Noncancer drinking water value protective of breast-feeding	0.0009	0.0008	0.008

	and formula-fed infants and older children			
Minnesota	Chronic Health Risk Limit	0.3	0.3	ND
Minnesota	Short-term, subchronic or chronic Health-based value	0.035	0.027	0.027[b]
Nevada	Basic comparison value	0.667	0.667	ND
New Jersey	Health-based chronic maximum contaminant level	0.014	0.013	ND
North Carolina	Interim maximum allowable concentration in groundwater	1.1-1.6	ND	ND
Texas	Drinking water screening level	0.03	0.06	0.009
Vermont	Drinking water health advisory	0.02[c]	0.02[c]	ND

a Maine Center for Disease Control and Prevention (MECDC) notes that USEPA indicates when both PFOS and PFOA are present in drinking water combined levels are not to exceed 0.07 ppb (USEPA 2016).
b Minnesota Department of Health (MDH) recommends using the health-based value for PFOS (0.027 ppb) as a surrogate for PFHxS until more toxicological research on PFHxS is available.
c Sum of PFOS and PFOA not to exceed 0.02 µg/L.
ND = no data
ppb = parts per billion
µg/L = micrograms per liter

In June of 2018, the Massachusetts Department of Environmental Protection (MassDEP) released the *Massachusetts Department of Environmental Protection Office of Research and Standards Final Recommendations for Interim Toxicity and Drinking Water Guidance Values for Perfluorinated Alkyl Substances Included in the Unregulated Chemical Monitoring Rule 3*. This document notes that PFHxS (and other long chain PFAS) exhibits a molecular structure and long biological half-life similar to PFOS and PFOA. The toxicity data reviewed by the MassDEP Office of Research and Standards (ORS) also indicates that PFHxS elicits similar types of effects at similar dose ranges as PFOS and PFOA. Based on its review, ORS recommended that the

USEPA health advisory values and reference doses (RfDs) derived for PFOS and PFOA be applied to PFHxS.

In addition, MassDEP recommended that an additive toxicity approach be used five longer-chain PFAs when they occur together. As such, when all or some of the five compounds PFOS, PFOA, PFHxS, perfluorononanoic acid (PFNA) and perfluoroheptanoic acid (PFHpA) occur together in drinking water, the detected concentrations should be totaled and compared to 0.07 ug/L. So, if PFOS, PFOA, and PFHxS are detected in drinking water at a site, the appropriate concentration (e.g., maximum detected concentration) of each of these PFAs should be summed and compared to 0.07 µg/L.

The USEPA drinking water advisories for PFOS and PFOA also describe the derivation of an RfD for these chemicals. An RfD of 2×10^{-5} mg/(kg·day) was calculated for both PFOS and PFOA.

ATSDR has derived intermediate-duration (15-365 days) oral MRLs for PFOS, PFOA, perfluorononanoic acid (PFNA) and PFHxS. The values were derived and presented in the revised *Toxicological Profile for Perfluoroalkyls (Draft of Public Comment)* dated June 2018. ATSDR calculated an MRL of 2×10^{-5} mg/(kg·day) for PFHxS, a value of 3×10^{-6} mg/(kg·day) for PFNA, and a value of 2×10^{-6} mg/(kg·day) for both PFOS and PFOA. For drinking water exposures, doses can be used to determine equivalent water concentrations using mathematical equations and information about a person's body weight and how much water they drink each day. ATSDR's calculations are based on the guidelines published in the Public Health Assessment Guidance Manual, and the EPA 2011 Exposure Factors Handbook. In addition to perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), and ATSDR has developed a MRL screening values for perfluorohexane sulfonic acid (PFHxS). ATSDR converts these screening levels into drinking water concentrations for children using the child's weight and water intake. ATSDR performs the calculation for an infant (age birth to one year old) weighing 7.8 kg and a water intake rate of 1.113 liters per day. For PFHxS (as well as other PFAS), NMED assumes exposure occurs from birth to six years of age and uses a body weight of 15 kg and a drinking water intake rate of 0.78 liters per day for a child of this age.

When ATSDR converts the MRL for PFHxS into a drinking water concentration the result is 140 parts per trillion (1.40E-02 µg/L) for the infant. A value of 3.85E-02 µg/L, rounded to 0.04 µg/L is obtained when the conversion is performed using the NMED-recommended parameter values for child body weight and daily water intake.

RECOMMENDATION

There appears to be sufficient information and precedence established by federal and state environmental agencies to recommend a path forward regarding evaluation of PFHxS in drinking water and via other exposure pathways. While a quantitative risk assessment for PFHxS could be conducted, given the evolution of evaluating the toxicity for this compound, it is recommended that any risks be qualitatively discussed in an uncertainty analysis. Results of the calculation of risk should not, at this time, be used to make regulatory decisions on closure or corrective action but should guide future decisions about a site pending more research on PFHxS toxicity.

The following human health guidelines are recommended:

- Based on similar molecular structure, similar health effects, and similar half-lives, health advisory values and RfDs developed for PFOS may be assigned to PFHxS.
- When evaluating groundwater data for ingestion as drinking water, and only PFHxS is detected, PFHxS should be evaluated against 0.04 µg/L obtained by converting the ATSDR MRL for PFHxS into a drinking water concentration using the child body weight and daily water intake recommended by NMED.
- When PFHxS and other longer-chain PFAs are detected in drinking water, the sum of the concentrations of all longer-chain PFAs should be compared to 0.07 µg/L. For example, if PFOS, PFOA, and PFHxS are all detected in the drinking water/groundwater sample, their concentrations should be summed, and the sum compared to 0.07 µg/L.

- When evaluating intake via the soil exposure pathway, screening levels for PFHxS should be evaluated using an RfD of 2 x 10^{-5} mg/(kg·day). Note that ATSDR determined an intermediate oral MRL of the same value for PFHxS. However, the EPA and ATSDR differ. For consistency, it is recommended that the USEPA RfD for PFOS be assumed, rather than the ATSDR MRL. The resulting soil screening levels derived using the exposure assumptions and methodologies in the NMED Soil Screening Guidance (NMED, 2017) results in the following screening levels:

Constituent	Residential (mg/kg)	Industrial (mg/kg)	Construction Worker (mg/kg)
PFHxS	1.56E+00	2.60E+01	7.08E+00

- Evaluation of PFHxS using these approaches constitutes a screening assessment to determine if PFHxS is a contaminant of potential concern at a site. The evaluation should not be considered a numerical indication of the noncarcinogenic risk resulting from exposure to the concentration or calculated intake for PFHxS.

Additional research is needed to assess ecological toxicity of PFHxS. At this time, potential exposure and risk to ecological receptors should be addressed in the uncertainties section of the risk assessment.

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