NEW MEXICO ENVIRONMENT DEPARTMENT

Risk Assessment Guidance for Site Investigations and Remediation

December 2014

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 three separate 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 July 2014 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.

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

- Volume I – Tier 1: Soil Screening Guidance Technical Background Document
- Volume II - Screening-Level Ecological Risk Assessments

Volume I contains 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 summarizes SSLs for select Aroclors and congeners of polychlorinated biphenyls (PCBs). Additional details for derivation of more site-specific SSLs for PCBs are contained within Appendix D.

Volume II provides guidance for conducting a scoping assessment for ecological risk as previously contained within the *Technical Background Document for Development of Soil Screening Levels.*

SUMMARY OF CHANGES

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

Item	Section	Change	Date
VOLUME I TIER 1: SOIL SCREENING GUIDANCE TECHNICAL BACKGROUND DOCUMENT			
1	Global	Update default exposure parameters; includes changes to text, tables, equations, and soil screening levels in Appendix A	November 2014
2	Global	General edits and clarifications	November 2014
3	Table of Acronyms	Updated	November 2014
4	Table of Contents	Updated	November 2014
5	Summary of Changes	Added new section summarizing changes to document by revision number and date	November 2014
6	Section 1.2.1 and Table 1-1	Addition of tap-water exposure, vapor intrusion and beef ingestion pathways	November 2014
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)	November 2014
8	Section 2.1.7	Section added addressing emerging contaminants	November 2014
9	Section 2.2.1 and Equations 12-17	Incorporated carcinogenic and mutagenic effects to calculation of trichloroethylene (TCE) specific soil screening levels	November 2014
10	Section 2.4	Modified to include dermal exposure	November 2014
11	Equations 24-26	Equations were modified and added to include dermal contact with tap water pathway	November 2014
12	Equation 27	Changed noncarcinogenic exposure parameters from adult exposure to child exposure (tap water)	November 2014
13	Equations 29-30 and Equations 31-35	Added dermal pathway to equations for vinyl chloride and mutagens	November 2014
14	Section 2.5	Section added addressing the vapor	November

Item	Section	Change	Date
		intrusion pathway and derivation of vapor screening levels	2014
15	Section 2.6	Section added describing the evaluation of the beef ingestion pathway	November 2014
16	Section 2.7.2	Section added describing background threshold values	November 2014
17	Section 2.7.3	Clarification added on determination of constituents of potential concern	November 2014
18	Section 2.7.7	Section added providing guidance for calculation of exposure-point concentrations	November 2014
19	Section 3.4	Added list of sources used for deriving chemical property information	November 2014
20	Section 5.0	Clarification added to text on the use of the SSLs	November 2014
21	Section 5.1	Section added describing chromium speciation and tiered approach to using chromium screening levels	November 2014
22	Section 5.2	Section added describing derivation of screening levels for essential nutrients	November 2014
23	Section 6.0	Updated Total Petroleum Hydrocarbon (TPH) methodology; removed groundwater screening levels.	November 2014
24	Section 7.0	Updated references	November 2014
25	Table A-1	Updated NMED screening levels	November 2014
26	Table A-2	Updated default exposure parameters	November 2014
27	Table A-3	Table added displaying vapor intrusion screening levels	November 2014
28	Tables B-1 and B-2	Updated chemical property information with references added	November 2014
29	Table B-3	Table added showing input parameters and chemical properties for dermal tap-water pathway	November 2014
30	Table C-1	Updated toxicity data	November 2014
VOLUME 2 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENTS			
1	Global	Updating of reference	November 2014
2	Global	General editorial corrections	November 2014
3	Section 3	Additional clarification of Screening Level	November

Item	Section	Change	Date
		Ecological Risk Assessments (SLERA) for Phase I – revised Tier 1 assessments and added updated methodologies and equations	2014
4	Section 4	Added Tier 2 SLERA methodologies and equations	November 2014
5	Section 5	Site-specific ecological risk assessments added as Tier 3 process	November 2014

VOLUME I
TIER 1: SOIL SCREENING GUIDANCE TECHNICAL BACKGROUND DOCUMENT

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LIST OF ACRONYMS

AI	Adequate Intake
ASTDR	Agency for Toxic Substances and Disease Registry
BGS	Below Ground Surface
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
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
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane Sulfonate
PPRTV	Provisional Peer-reviewed Toxicity Value
PRG	Preliminary Remediation Goal
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RCRA	Resource Conservation and Recovery Act

LIST OF ACRONYMS, Cont.

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	Tricholorethylene
TEF	Toxicity Equivalency Factor
TEQ	Toxicity Equivalent
TPH	Total Petroleum Hydrocarbon
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. Screening levels for the vapor intrusion pathway are presented in Table A-3 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.

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, the SSLs preferentially report the screening value representative of the lowest (most stringent) contaminant concentration in environmental media. 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.

In the event that 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, 2014a 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., 90th to 95th 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 non-carcinogenic 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 take into account 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 non-carcinogenic 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 non-carcinogenic 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.

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), VISLs, and beef ingestion SLs 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-3.

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, 2014a):

1) Integrated Risk Information System (IRIS) (US EPA, 2014c) (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 following TEFs should be applied to the analytical results and summed for each sample location; the sum, or toxicity equivalent (TEQ), should be compared to the NMED SSL for 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD).

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

Dioxin and Furan Congeners	TEF
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 of the other Aroclors were considered 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

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. The US EPA recommended levels for lead, based on blood-lead modeling (Integrated Exposure Uptake Biokinetic Model, IEUBK) were applied.

Total Chromium. Toxicity data for total chromium were adjusted based on a ratio of 1:6 (hexavalent chromium: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):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.

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

Poylycyclic 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

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. In the event that the hazard index results in a value above the target level of 1, 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 non-carcinogenic 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. These contaminants may include but are not limited to perfluorinated compounds, such as perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). 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 specifically PFOAs and PFOSs, 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, 2014b).

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 90th percentile of the length of time someone lives in a single location (US EPA, 2014b)], remaining onsite for 350 days per year. Exposure to soil (to depths of zero to 10 feet below ground surface) 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 and 56).

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 1 and 2 are used to calculate cumulative SSLs for a residential receptor exposed to non-carcinogenic 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 1. 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 non-carcinogens, 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, 2014b). 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 3 and 4 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 2 to develop generic NMED SSLs for carcinogenic effects.

Equation 1
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 45
PEF_w	Particulate emission factor (m^3/kg)	See Equation 48

Equation 2
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 3
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
DFS_{adj}	Age-adjusted dermal factor (mg/kg)	See Equation 4
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 45
PEF	Particulate emission factor (m^3/kg)	See Equation 48

Equation 3
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 4
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 1 and 2 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 5. As vinyl chloride does not have an adsorption factor, dermal risks are not assessed.

Equation 5
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 3
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 43

Equations 6 through 11 show the derivation of the SSLs for carcinogenic chemicals exhibiting mutagenic properties. Mutagenicity is only assessed for the residential scenario.

Equation 6
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 7
10^{-6}	Conversion factor (kg/mg)	10^{-6}

Equation 7
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 8
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 45
PEF	Particulate emission factor (m^3/kg)	See Equation 48

Equation 9
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 10
ABS_d	Skin absorption factor (unitless)	Chemical-specific
10^{-6}	Conversion factor (kg/mg)	10^{-6}

Equation 10
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 11.

Equation 11
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 6
C_{mu-inh}	Concentration from inhalation (mg/kg)	See Equation 8
$C_{mu-dermal}$	Concentration from dermal exposure (mg/kg	See Equation 9

For trichloroethylene (TCE), the US EPA IRIS (US EPA, 2014c) 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 12 through 17 allow assessment of both cancer and mutagenic effects.

Equation 12
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 13
IFS_{adj}	Age-adjusted soil ingestion factor for carcinogens (mg/kg)	See Equation 6
MAF_o	Adjusted oral mutagenic slope factor $(mg/kg\text{-}day)^{-1}$	See Equation 13
$IFSM_o$	Age-adjusted soil ingestion factor for mutagens (mg/kg)	See Equation 7

Equation 13
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 14
SSL for Inhalation of Soil- TCE

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

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

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 15
MAF_i	Adjusted inhalation mutagenic unit risk $(\mu g/m^3)^{-1}$	See Equation 15
VF_s	Volatilization factor for soil (m^3/kg)	See Equation45
PEF	Particulate emission factor (m^3/kg)	See Equation 48

Equation 15
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 16
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 13
DFS_{adj}	Resident soil dermal contact factor- age-adjusted (mg/kg)	See Equation 4
ABS	Skin absorption factor (unitless)	Chemical-specific
MAF_o	Oral mutagenic slope factor $(mg/kg\text{-}day)^{-1}$	See Equation 13
$DFSM_{adj}$	Resident Mutagenic soil dermal contact factor- age-adjusted (mg/kg)	See Equation 10

Equation 17
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
$SSL_{res-TCE}$	Cumulative SSL for mutagens (mg/kg)	Chemical-specific
$C_{TCE-oral}$	Concentration from soil ingestion (mg/kg)	See Equation 12
$C_{TCE-inh}$	Concentration from inhalation (mg/kg)	See Equation 14
$C_{TCE-der}$	Concentration from dermal exposure (mg/kg)	See Equation 16

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 (USEPA, 2014b).

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 work day as either (1) a full time employee of a company operating on-site who spends most of the work day 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 below ground surface) 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 18 and 19 were used to develop generic SSLs for cumulative exposure to carcinogenic and non-carcinogenic contaminants by all exposure pathways. Default exposure parameters (US EPA 2002a and US EPA 2014b) are provided and were used in calculating the NMED SSLs.

Equation 18
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 45
PEF	Particulate emission factor (m^3/kg)	See Equation 48

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

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

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

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

<u>Combined Exposures:</u>

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

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 45
PEF	Particulate emission factor (m^3/kg)	See Equation 48

2.3.2 Construction Worker

A construction worker is assumed to be a receptor that is exposed to contaminated soil during the work day 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 20 and 21 were used to develop generic SSLs for cumulative exposure to carcinogenic and non-carcinogenic contaminants by all exposure pathways for a construction worker. Default exposure parameters (US EPA 2002a and US EPA 2014b) are provided and were used in calculating the NMED SSLs.

Equation 20
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 46
PEF_{cw}	Particulate emission factor, construction worker (m^3/kg)	See Equation 49

Equation 21
Combined Exposures to Noncarcinogenic Contaminants in Soil
Construction Worker Scenario

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

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

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

<u>Combined Exposures:</u>

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

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 46
PEF_{cw}	Particulate emission factor, construction worker (m^3/kg)	See Equation 49

2.3.3 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 the 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 (US EPA 1994 and 1998). 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). It is also used for adults in evaluating occupational scenarios at sites where access by children is reliably restricted. The NMED SSLs presented in Appendix A include values for lead that were calculated by using the IEUBK 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).

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, 2014b). 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 22 through 28 show how SLs for

carcinogenic and non-carcinogenic contaminants were developed. Similar to soil, separate equations are used for vinyl chloride (Equations 29 and 30) and carcinogens exhibiting mutagenic toxicity (Equations 31-35) such as trichloroethylene.

Equation 22
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 24-26)	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 23)	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 23
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 24
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 25
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 26

Equation 25
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 26
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)	2,721,670
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)	6,378
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)	20,900
BW_a	Body weight, adult (kg)	80

Equation 27
Combined Exposures to Noncarcinogenic Contaminants in Tap Water
Residential Scenario

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

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

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

<u>Combined Exposures:</u>

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

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration, ingestion (µg/L)	Chemical-specific
C_{derm}	Contaminant concentration, dermal (µg/L)	See Equation 28
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 28
Dermal Exposure to Non-carcinogenic 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, non-carcinogens (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)	6,378

Equation 29
Combined Carcinogenic Exposures to Vinyl Chloride in Tap Water
Residential Scenario

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

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

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

<u>Combined Exposures:</u>

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

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration, ingestion (µg/L)	Chemical-specific
C_{derm}	Contaminant concentration, dermal (µg/L)	See Equation 30
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 23
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 30
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 25
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 26
EV_c	Event duration, child (events/day)	1
SA_c	Skin surface area available for contact, child (cm^2)	6,378
BW_c	Body weight, child (kg)	15

Equation 31
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
$C_{mu-oral}$	Contaminant concentration, ingestion (µg/L)	Chemical-specific
$C_{mu-derm}$	Contaminant concentration, dermal (µg/L	See Equations 33-35
C_{mu-inh}	Contaminant concentration, inhalation (µg/L)	Chemical-specific
SL_{tap-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-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 32
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
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific

Equation 32
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 33
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 34
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 35

Equation 34
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 35
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)	8,419,740
$EV_{0\text{-}2}$	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)	6,378
$EV_{2\text{-}6}$	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)	20,900
$EV_{16\text{-}26}$	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 36
Combined Exposures to TCE in Tap Water
Residential Exposure

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

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

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

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

<u>Combined Exposures:</u>

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

Parameter	Definition (units)	Default
$C_{TCE\text{-}oral}$	Contaminant concentration, ingestion (µg/L)	Chemical-specific
$C_{TCE\text{-}derm}$	Contaminant concentration, dermal (µg/L) (See Equations 37-39)	Chemical-specific
$C_{TCE\text{-}inh}$	Contaminant concentration, inhalation (µg/L)	Chemical-specific
$SL_{tap\text{-}TCE}$	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 13
IFW_{adj}	Age-adjusted ingestion oral ingestion factor (L/kg)	See Equation 23
MAF_o	Age-adjusted mutagenic slope factor (µg/m^3)$^{-1}$	See Equation 13
$IFWM_{adj}$	Age-adjusted water ingestion rate, mutagens (L/kg)	See Equation 32
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 15
MAF_i	Adjusted inhalation mutagenic unit risk (µg/m^3)$^{-1}$	See Equation 15
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

Equation 37
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 25
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 34
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 13
MAF_o	Adjusted oral mutagenic slope factor	See Equation 13
DFW_{adj}	Age-adjusted dermal tap water exposure factor, resident (cm^2-event /kg)	See Equation 26
$DFWM_{adj}$	Age-adjusted dermal tap water exposure factor, mutagens, resident (cm^2-event /kg)	See Equation 35

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,

2002d), 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 life time 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, 2014d) and NMED-specific input parameters and are summarized in Table A-3. The list of chemicals included in Table A-3 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-3, VISLs should be calculated following the methodologies herein and risks addressed..

The US EPA (2002d) 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).

2.5.1 Calculation of Vapor Intrusion Screening Levels

NMED VISLs were calculated per US EPA (2002d, 2009, and 2013b) 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 a number of 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 (2002d and 2013b), a default attenuation factor of 0.11 was applied to establish soil-gas VISLs, and a default attenuation factor of 0.0012 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 38. Equation 39 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.

1 The USEPA's draft guidance for vapor intrusion (November 2012) proposes a new value of 0.03 for the attenuation of soil gas. This guidance is under review; upon finalization of the guidance, the default attenutation factor for soil gas will be evaluated and if warranted, new generic VISLs will be evaluated and a revision to this NMED guidance issued.

2 The USEPA's draft guidance for vapor intrusion (November 2012) proposes no change to the groundwater attenuation factor (0.001) as presented herein.

Equation 38
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)	0.1 (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 in order to be protective of all sites in New Mexico.

The risk-based target indoor air concentrations were calculated using US EPA (2009, 2013b, and 2014b) algorithms, current toxicity data, and exposure factors used in the evaluation of other exposure pathways outlined in this document. Equations 39 through 42 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 43 through 55 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 39
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 40
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 41
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 42
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_{0-2}	Exposure duration (0-2 yr)	2
ED_{2-6}	Exposure duration (2-6 yr)	4
ED_{6-16}	Exposure duration (6-16 yr)	10
ED_{16-26}	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 43
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 44
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 indicate 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 1×10^{-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-3 contains the VISLs for chemicals which met these three criteria. However, this list in Table A-3 is <u>not</u> comprehensive and any additional compounds meeting the above three criteria not listed in Table A-3 and present in site media will require additional analyses following the methods contained herein.

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

If volatile and toxic compounds are not detected in soil gas and/or groundwater, meaning all the results were 100% non-detects, then the vapor intrusion pathway is considered incomplete. The risk assessment must include a brief discussion of this determination.

2.5.2.2 Potentially Complete Pathway; Qualitative Discussion

If <u>all</u> of 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-3);
- 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-3),
- 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 57 and 58. 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, procede to Step 2.

Step 2. Under previous guidance, more refined modeling for the vapor intrusion pathway was typically conducted using the Johnson and Ettinger (J&E) model (US EPA, 2004b). However, in looking at new (draft) USEPA guidance, if initial screening using VISLs results in excess risk, USEPA is leaning away from use of the J&E model and is proposing a lines of evidence and additional data collection approach. 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 at the same time that coinciding subslab soil gas and indoor air samples are taken.
- 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), a qualitative assessment of this pathway must be provided. However, if grazing is viable or if a facility may potentially allow grazing on lands at some time in the future, a quantitative assessment of the pathway, ingestion of beef from cattle grazing on potentially contaminated sites, is required. The preliminary remediation goals (PRGs) for beef ingestion from the Risk Assessment Information System (RAIS) on-line tool should be used to assess this pathway. The steps to determine the beef ingestion PRGs are listed below:

- Access the on-line PRG calculator (http://rais.ornl.gov/cgi-bin/prg/PRG_search?select=chem),
- Select farmer scenario,
- Select site-specific PRG type and chronic toxicity,
- Select chemical(s) of concern,
- Select "Retrieve",
- Under "Common parameters for ingestion of Produce, Milk, and Beef", update the following parameters:
    - BWa (body weight - adult) 80 kg
    - EDag (exposure duration - resident) 26 yr
    - TR (target cancer risk) 1E-05 unitless
- Under "PRG for Contaminated Food Products", obtain the PRG for ingestion of beef (cancer and non-cancer as appropriate).

Once the beef ingestion PRGs have been determined, site concentrations should be compared with the beef ingestion PRGs and estimated risks and hazards should be added to the cumulative risk/hazards as shown in Equations 57 and 58.

2.7 Site Assessment and Characterization

The Site Assessment/Site Characterization phase is intended to provide additional 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. In addition, the site assessment phase serves as the initial information gathering phase to determine whether potential exposures are sufficiently similar to those upon which the NMED SSLs are predicated to support comparison. Finally, this phase can help to identify sites in need of a more detailed assessment of potential risk. A CSM providing a list of the potentially exposed receptors and potentially complete exposure pathways in the scoping report is used to determine whether further assessment (i.e., a screening level assessment) and/or 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 with regard to contaminant contact by receptors? A complete site assessment will consists of several steps:

- Develop data quality objectives and conduct site sampling;
- Determine background threshold values (BTVs);
- Identify preliminary COPCs;
- Develop a preliminary site conceptual exposure model (SCEM);
- Determine exposure intervals;
- Compare maximum COPC concentrations for consideration of complete exposure pathways with SSLs; and
- 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).

2.7.1 Development of Data Quality Objectives

Before any additional 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, 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 ahould be established during a site-specific soil background study, as approved by NMED. Sample size, locations, other site-specific parameters for background data sets should be outlined during the DQO process as presented in the 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 a sufficient number of data for statistical analyses;
- Free of 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 are 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 (2013a) 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 in order 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, 2013a). 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 in order 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. The exception to this would be on a case-by-case basis where 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.

2.7.3 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.

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.

For inorganics, a comparison of site concentrations to appropriate background concentrations may be conducted prior to evaluation against SSLs. Those inorganics that are present at levels indicative of natural background may be eliminated as COPCs. Comparison to background must be conducted following current US EPA Guidance and as outlined herein. The general process is a tiered approach.

<u>Step 1.</u> Compare the maximum detected site concentration to the site-specific background reference values (upper tolerance limit) determined for each soil type 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 is not retained as a COPC. If there is no background value for a constituent, then it will be retained as a COPC.

<u>Step 2:</u> 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.

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. In addition, a review of graphical displays (e.g., box plots and Q-Q plots) may also be provided in order to provide further justification in determining whether site concentrations are elevated compared with background. These graphical plots can be also be generated by ProUCL software.

Note that the above two-sample test can only be used for site data sets that have a sufficient number of samples (i.e., $n \geq 8$) and number of detections (i.e, ≥ 5 detected observations). While a minimum of 10 background data samples are now required, there may be sites where background has been previously conducted and may contain fewer than 10 samples. Site-to-background point-by-point comparisons will be conducted for site data sets containing fewer than eight samples and fewer than five detected observations. As stated in the current version of ProUCL User's Guide (US EPA, 2013a), hypothesis testing is only considered to be reliable with sufficient sample size ($n \geq 8$) and frequency of detection (≥ 5 detected observations). 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 an inorganic as being site related, such as site history, number of non-detects, etc. For areas where a hotspot may be present, additional actions are required and the constuent(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) or simple comparison to a range of data are not acceptable lines of evidence.

2.7.4 Development of a Preliminary Conceptual Site Model

A CSM is a graphical representation of three-dimensional 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 that were not considered in development of the SSLs (e.g. vapor intrusion, direct exposure to groundwater, local fish consumption,

raising homegrown produce, beef, dairy, or other livestock)? (refer to US EPA 1989).

- Are there potential ecological concerns? (*Guidance for Assessing Ecological Risks Posed by Chemicals: Screening Level Ecological Risk Assessment*; NMED 2014).

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

2.7.5 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 2 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 can 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 0-10 feet bgs should be assessed for burrowing animals. Maximum COPC concentrations in soil 0-5 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
Ecological Receptors (non-burrowing)	0 – 5 ft bgs
Ecological Receptors (burrowing)	0 – 10 ft bgs

2.7.6 Compare COPC Maximum Concentrations with SSLs

The final step in the site assessment phase is to compare maximum detected COPC concentrations in soil with SSLs based on the complete exposure pathways identified by the preliminary CSM and assessing total risk/hazard from all constituents (refer to Section 5). These concentrations should also be compared against the SSL leaching values to determine which contaminants present in soil have the capacity to leach to underlying groundwater and impact these resources adversely. As stated earlier, those contaminants exhibiting concentrations in excess of the SSLs represent the initial soil COPC list for a given site. Refinement of this list may be necessary based on a host of factors, including elevated detection or quantitation limits.

2.7.7 Calculation of Exposure Point Concentrations

If it is determined that further assessment is warranted (see Section 5), refinement of EPCs should be conducted. US EPA (1989) recommends using the average 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."

Upper confidence limits should only be calculated for data sets that meet the US EPA (2013a) 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 six 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, 2013a). Therefore, UCLs should only be calculated for data sets that meet the minimum requirements for calculation UCLs.

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, ProUCL guidance recommends regression on order statistics methods for handling non-detects in environmental data sets. 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.

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 2014a), 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 45 while the $VF_{s\text{-}cw}$ for the construction worker is calculated using Equation 46.

Equation 45
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 46
Derivation of the Volatilization Factor for Construction Worker Scenario

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

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
$VF_{s\text{-}cw}$	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 45 and 46 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 47, given below is used to calculate C_{sat} for each volatile contaminant considered within the SSLs.

Equation 47
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 47 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 2014a), 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 48 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 49.

Equation 48
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 49
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.

$$H = \frac{VP \text{ x } MW}{S} \qquad \textbf{Equation 50}$$

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:

$$K_{oc} = \frac{\text{concentration adsorbed/concentration dissolved}}{\text{\% organic carbon in soil}} \qquad \textbf{Equation 51}$$

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:

$$K_d = K_{oc} \text{ x } f_{oc}$$ **Equation 52**

Where:

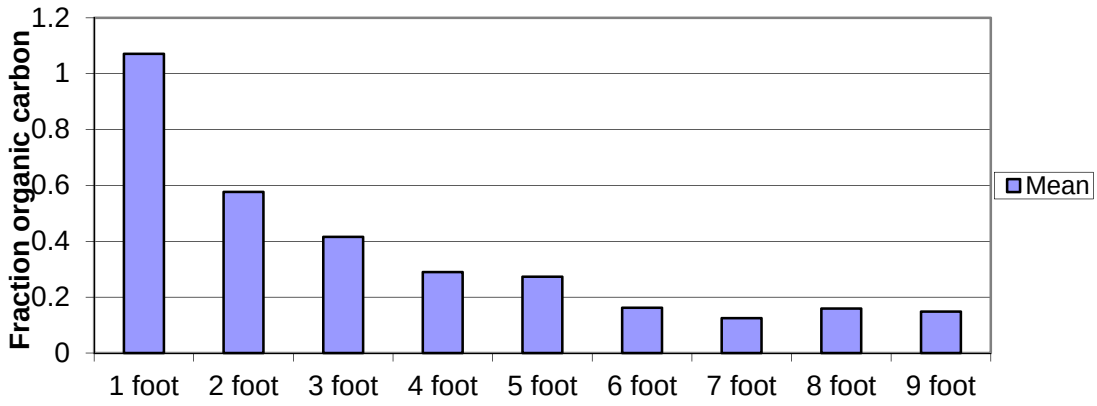
K_{oc} = organic carbon partition coefficient (L/kg or cm^3/g); and
f_{oc} = fraction of organic carbon in soil (mg/mg).

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:

$$\log K_d = 1.01 \log K_{ow} - 0.36$$ **Equation 53**

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 USEPA'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 take into account 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. 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 are presented, the generic model and the site-specific model. Both models use the same set of equations to calculate SSLs and are based on leaching to groundwater scenarios that NMED believes are protective of groundwater. The generic model calculates 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 soil leachate 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 an SSL that is protective of groundwater using a simple linear equilibrium soil/water partition equation. For the generic 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 SSL model. The site-specific model uses the same spreadsheet equations to calculate 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

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 54, given below, is used to calculate SSLs corresponding to target soil leachate concentrations (C_w).

Equation 54
Soil Screening Level For Leaching To Groundwater Pathway

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

Parameter	Definition (units)	Default
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.

$$C_w = \text{Tap Water SSL x DAF} \qquad \textbf{Equation 55}$$

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 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 56), described below.

Equation 56
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 SSLs, the DAF is used to back calculate the target soil leachate concentration (C_w in Equation 55) from an appropriate groundwater concentration, such as the tap water SSL, a Water Quality Control Commission (WQCC) standard, or a Federal Maximum Contaminant Level (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 SSL water balance dilution model (Equation 55) 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 56), 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 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 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 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 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 SSLs, a DAF of 20 is selected as reasonably protective. However SSLs are provided for two DAFs in Appendix A. The use of the 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 an SSL using the migration to groundwater pathway model is most sensitive to the DAF. The inclusion of the SSL for a DAF of 1 is 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 SSL for a DAF of 1 to provide a site-specific SSL.

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 SSLs.

4.7 Development of Site Specific 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 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 soil leachate SSLs 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 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 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 SSLs can be readily substituted with a more representative site-derived value. Conversely, limited site-specific data may restrict the number of default values to be replaced.

The NMED 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, SSLs 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 SSLs, 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 SSL 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 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 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 SSL.

Table 4-1. Input Parameters and Resulting 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 SSLs
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 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	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 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 SSLs are developed for a 30 acre source, then

those values are considered overly conservative for a 12 acre source. Conversely, 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 meters (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 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 SSL Development

Sites that have complex or heterogeneous subsurface conditions may require more detailed evaluation for development of 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 SSLs

SSLs for New Mexico have been developed for the migration to groundwater pathway, and are provided in Table A-1 of Appendix A. The NMED SSLs were developed using default parameter values representative of environmental conditions in New Mexico and utilize a DAF of 20. This approach maintains the conservative approach of the SSL methodology and is protective of groundwater quality under a wide range of site conditions. Soil contaminant concentrations can be compared directly to the generic SSLs 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-specific tap water SSLs.

Site-specific SSLs can be developed by substituting site-related data for the default values in the leaching to groundwater pathway model. SSLs developed from this model are most sensitive to the DAF. 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.

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 57. Equation 58 shows the sum of the ratios is multiplied by the NMED target hazard of 1.0 for non-carcinogens.

$$\text{Site Risk} = \left(\frac{\text{conc}_x}{\text{SSL}_x} + \frac{\text{conc}_y}{\text{SSL}_y} + \frac{\text{conc}_z}{\text{SSL}_z} + \ldots + \frac{\text{conc}_i}{\text{SSL}_i} \right) \times 10^{-5} \qquad \textbf{Equation 57}$$

$$\text{Site Hazard Index (HI)} = \left(\frac{\text{conc}_x}{\text{SSL}_x} + \frac{\text{conc}_y}{\text{SSL}_y} + \frac{\text{conc}_z}{\text{SSL}_z} + \ldots + \frac{\text{conc}_i}{\text{SSL}_i} \right) \times 1 \qquad \textbf{Equation 58}$$

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 57 and 58. 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.

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. An exposure interval of 0-5 ft bgs should be assumed for non-burrowing ecological receptors and shallow rooted plants, and an exposure interval of 0-10 ft bgs should be assumed

for burrowing receptors and deep rooted plants. 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 57 and 58. 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 paramters is appropriate.

5.1 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).

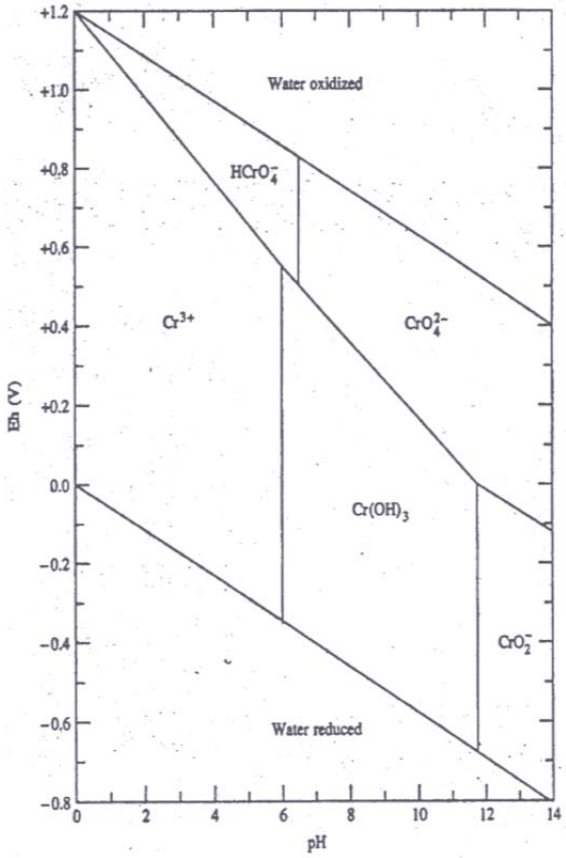


Figure 5-1. Eh-pH Diagram for Chromium

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 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.

5.2 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 the exposure assumptions in Equation 59 for ingestion of soil only and are presented in Table 5-1.

Table 5-1. Soil Screening Levels for Essential Nutrients

Essential Nutrient and Receptor	Upper Level (UL) or Adequate Intake (AI) (mg/day)		Soil Screening Level (mg/kg)
Calcium			
Industrial Worker	2000	UL	3.24E+07
Resident	2500	UL	1.30E+07
Construction worker	2000	UL	8.85E+06
Chloride			
Industrial Worker	3400	UL	5.52E+07
Resident	2300	UL	1.20E+07
Construction worker	3400	UL	1.50E+07
Magnesium			
Industrial Worker	350	UL	5.68E+06
Resident	65	UL	3.39E+05
Construction worker	350	UL	1.55E+06
Phosphorous			
Industrial Worker	3000	UL	4.87E+07
Resident	3000	UL	1.56E+07
Construction worker	3000	UL	1.33E+07
Potassium			
Industrial Worker	4500	AI	7.30E+07
Resident	3000	AI	1.56E+07
Construction worker	4500	AI	1.99E+07
Sodium			
Industrial Worker	2200	UL	3.57E+07
Resident	1500	UL	7.82E+06
Construction worker	2200	UL	9.73E+06

ULs and AIs taken from The National Academies Press (2011 and 2006)

Equation 59
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

If the maximum detected concentration of an essential nutrient at a site is below the soil SSLs, 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.

6.0 TOTAL PETROLEUM HYDROCABONS (TPH)

In some instances, it may be practical to assess areas of soil contamination that are the result of releases of petroleum products using total petroleum hydrocarbon (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, threat to ground water, and vapor intrusion. 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 based on reasonable assumptions about the composition of petroleum products commonly found at contaminated sites, as shown in Table 6-1.

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

Petroleum Product	C11-C22 Aromatics	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%

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

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/Occupational 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	Not applicable	Not applicable

Mineral oil based hydraulic fluids can be evaluated for petroleum fraction toxicity using the screening guidelines from Table 6-2 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). 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. Potential soil vapor impacts shall be evaluated for individual petroleum-related contaminants listed in Table A-1 and following the methodology in Section 2.5 of this guidance.

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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.

Table A-1

Column 1: The first column in Table A-1 presents the names of the chemicals for which NMED has developed SSLs.

Column 2: The second column presents NMED SSLs predicated on residential soil exposures.

Column 3, 5, 7, and 9: These columns present indicator categories for the NMED SSL residential, industrial, construction, and tap water basis, whether predicated on carcinogenic (c) and noncarcinogenic (n) effects. In some cases, the risk-based SSL is greater than the soil saturation limit, and in these cases, the SSL is denoted as either “cs” or “ns” depending on carcinogenicity or non-carcinogenicity, respectively. In the case where a noncarcinogenic SSL is greater than the ceiling limit (1E+05), the SSL is denoted as “nl” and in a few cases, “nls” is used to indicate the SSL is both above the saturation level and the ceiling limit. NMED SSLs predicated on a carcinogenic endpoint reflect age-adjusted child-to-adult exposures. NMED SSLs predicated on a noncarcinogenic endpoint reflect child-only exposures. Detected concentrations above a saturation value (“cs”, “ns”, or “nsl”) may indicate the presence of nonaqueous phase liquid (NAPL).

Columns 4 and 6: The fourth and sixth columns present NMED SSLs analogous to Column 1, with the exception that these values correspond to Industrial/Occupational and Construction worker (adult-only) exposures, respectively.

Column 8: Presents the tap water SL for the residential scenario.

Columns 10 and 11: The tenth column presents NMED SSLs for the migration to groundwater pathway developed using a default dilution attenuation factor (DAF) of 1, which assume no effective dilution or attenuation. These values can be considered at sites where little or no dilution or attenuation of soil leachate concentrations is expected (e.g., shallow water tables, karst topography). Column 11 presents NMED SSLs for the migration to groundwater pathway developed using a DAF of 20 to account for natural processes that reduce contaminant concentrations in the subsurface. The SSLs based on a DAF of 20 are default SSLs that should be applicable at most sites.

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 environmentally-impacted 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-3 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 life time 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-3 are sufficiently volatile and toxic to be considered for the vapor intrusion pathway. The list of chemicals included in Table A-3 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-3, 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-3

Column 1:	The first column in Table A-3 presents the names of the chemicals for which NMED has developed VISLs.
Columns 2 and 6:	These columns present NMED indoor air screening levels predicated on residential and commercial/industrial exposures, respectively. These indoor air screening levels were used to derive VISLs for soil-gas and groundwater.
Columns 3 and 7	These columns present indicator categories for the NMED indoor air residential and commercial/industrial screening levels, whether predicated on carcinogenic (c) or noncarcinogenic (n) effects.
Columns 4 and 8:	The fourth and eighth columns present NMED VISLs for volatiles detected in soil-gas for the residential and commercial/industrial exposures, respectively.
Columns 5 and 9:	The fifth and ninth columns present NMED VISLs for volatiles detected in groundwater for the residential and commercial/industrial exposures, respectively.

Table A-1: NMED Soil Screening Levels

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
Acenaphthene	3.48E+03	n	5.05E+04	n	1.51E+04	n	5.35E+02	n	4.12E+00	8.25E+01
Acetaldehyde	2.49E+02	n	1.17E+03	n	2.17E+02	n	1.88E+01	n	3.29E-03	6.58E-02
Acetone	6.63E+04	n	9.60E+05	nls	2.42E+05	nls	1.41E+04	n	2.49E+00	4.98E+01
Acrylonitrile	4.93E+00	c	2.46E+01	c	3.52E+01	n	5.23E-01	c	9.77E-05	1.95E-03
Acetophenone	7.82E+03	ns	1.30E+05	nls	3.54E+04	ns	1.92E+03	n	4.82E-01	9.64E+00
Acrolein	4.54E-01	n	2.16E+00	n	4.01E-01	n	4.15E-02	n	7.29E-06	1.46E-04
Aldrin	3.11E-01	c	1.50E+00	c	8.07E+00	n	4.54E-02	c	5.60E-03	1.12E-01
Aluminum	7.80E+04	n	1.29E+06	nl	4.14E+04	n	1.99E+04	n	2.99E+04	5.97E+05
Anthracene	1.74E+04	n	2.53E+05	nl	7.53E+04	n	1.72E+03	n	4.25E+01	8.51E+02
Antimony	3.13E+01	n	5.19E+02	n	1.42E+02	n	7.26E+00	n	3.28E-01	6.56E+00
Arsenic	4.25E+00	c	2.15E+01	c	5.74E+01	n	5.13E-01	c	1.50E-02	2.99E-01
Barium	1.56E+04	n	2.55E+05	nl	4.39E+03	n	3.28E+03	n	1.35E+02	2.70E+03
Benzene	1.78E+01	c	8.72E+01	c	1.42E+02	n	4.54E+00	c	1.90E-03	3.80E-02
Benzidine	5.18E-03	c	1.12E-01	c	8.12E-01	c	1.07E-03	c	2.09E-06	4.17E-05
Benzo(a)anthracene	1.53E+00	c	3.23E+01	c	2.40E+02	c	3.43E-01	c	9.11E-02	1.82E+00
Benzo(a)pyrene	1.53E-01	c	3.23E+00	c	2.40E+01	c	3.43E-02	c	3.02E-02	6.05E-01
Benzo(b)fluoranthene	1.53E+00	c	3.23E+01	c	2.40E+02	c	3.43E-01	c	3.09E-01	6.17E+00
Benzo(k)fluoranthene	1.53E+01	c	3.23E+02	c	2.31E+03	c	3.43E+00	c	3.02E+00	6.05E+01
Beryllium	1.56E+02	n	2.58E+03	n	1.48E+02	n	1.24E+01	n	9.79E+00	1.96E+02
a-BHC (a-Hexachlorocyclohexane, a-HCH)	8.45E-01	c	4.07E+00	c	2.97E+01	c	6.80E-02	c	2.98E-04	5.96E-03
b-BHC (b-Hexachlorocyclohexane, b-HCH)	2.96E+00	c	1.43E+01	c	1.04E+02	c	2.38E-01	c	1.04E-03	2.09E-02
g-BHC (Lindane)	5.63E+00	c	2.83E+01	c	9.43E+01	n	4.08E-01	c	1.79E-03	3.58E-02
1,1-Biphenyl	6.32E+01	n	2.98E+02	n	5.46E+01	n	8.34E-01	n	6.56E-03	1.31E-01
Bis(2-chloroethyl) ether	3.11E+00	c	1.57E+01	c	1.95E+00	c	1.36E-01	c	3.03E-05	6.05E-04
Bis(2-chloroisopropyl) ether	9.93E+01	c	5.19E+02	cs	3.54E+03	cs	9.76E+00	c	2.37E-03	4.73E-02
Bis(2-ethylhexyl) phthalate	3.80E+02	c	1.83E+03	c	5.38E+03	n	5.56E+01	c	9.99E+00	2.00E+02
Bis(chloromethyl) ether	2.08E-03	c	1.02E-02	c	4.81E-02	c	7.20E-04	c	1.50E-07	3.00E-06
Boron	1.56E+04	n	2.59E+05	nl	5.14E+04	n	3.95E+03	n	1.25E+01	2.51E+02
Bromodichloromethane	6.19E+00	c	3.02E+01	c	1.43E+02	c	1.34E+00	c	3.10E-04	6.21E-03
Bromomethane	1.77E+01	n	9.45E+01	n	1.79E+01	n	7.54E+00	n	1.71E-03	3.43E-02
1,3-Butadiene	6.86E-01	c	3.41E+00	c	2.02E+00	n	1.80E-01	c	1.04E-04	2.07E-03

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
2-Butanone (Methyl ethyl ketone, MEK)	3.74E+04	n	4.11E+05	nls	9.17E+04	ns	5.56E+03	n	1.00E+00	2.01E+01
tert-Butyl methyl ether (MTBE)	9.75E+02	c	4.82E+03	c	2.42E+04	cs	1.43E+02	c	2.77E-02	5.53E-01
Cadmium	7.05E+01	n	1.11E+03	n	7.21E+01	n	6.24E+00	n	4.69E-01	9.39E+00
Carbon disulfide	1.55E+03	ns	8.54E+03	ns	1.62E+03	ns	8.10E+02	n	2.21E-01	4.42E+00
Carbon tetrachloride	1.07E+01	c	5.25E+01	c	2.02E+02	n	4.53E+00	c	1.66E-03	3.33E-02
Chlordane	1.77E+01	c	8.90E+01	c	1.53E+02	n	2.23E+00	c	1.13E-01	2.26E+00
2-Chloroacetophenone	1.72E+05	nl	8.12E+05	nl	2.81E+02	n				
2-Chloro-1,3-butadiene	1.75E-01	c	8.48E-01	c	3.95E+00	c	1.87E-01	c	9.83E-05	1.97E-03
1-Chloro-1,1-difluoroethane	1.09E+05	nls	5.15E+05	nls	9.58E+04	ns	1.04E+05	n	5.34E+01	1.07E+03
Chlorobenzene	3.78E+02	ns	2.16E+03	ns	4.12E+02	ns	7.76E+01	n	4.18E-02	8.36E-01
1-Chlorobutane	3.13E+03	ns	5.19E+04	ns	1.42E+04	ns	6.31E+02	n	2.27E-01	4.53E+00
Chlorodifluoromethane	1.02E+05	nls	4.83E+05	nls	8.98E+04	ns	1.04E+05	n	4.27E+01	8.55E+02
Chloroform	5.90E+00	c	2.87E+01	c	1.34E+02	c	2.29E+00	c	5.46E-04	1.09E-02
Chloromethane	4.11E+01	c	2.01E+02	c	2.35E+02	n	2.03E+01	c	4.76E-03	9.51E-02
b-Chloronaphthalene	6.26E+03	n	1.04E+05	nl	2.83E+04	ns	7.33E+02	n	2.85E+00	5.70E+01
o-Chloronitrobenzene	1.78E+01	c	8.55E+01	c	8.39E+01	n	2.35E+00	c	1.71E-03	3.42E-02
p-Chloronitrobenzene	6.16E+01	n	9.16E+02	n	2.57E+02	n	1.79E+01	n	1.28E-02	2.57E-01
2-Chlorophenol	3.91E+02	n	6.49E+03	n	1.77E+03	n	9.10E+01	n	5.76E-02	1.15E+00
2-Chloropropane	2.86E+02	n	1.35E+03	ns	2.51E+02	ns	2.09E+02	n	6.31E-02	1.26E+00
o-Chlorotoluene	1.56E+03	ns	2.60E+04	ns	7.08E+03	ns	2.33E+02	n	1.78E-01	3.56E+00
Chromium III	1.17E+05	nl	1.95E+06	nl	5.31E+05	nl	1.36E+04	n	2.46E+07	4.91E+08
Chromium VI	3.05E+00	c	7.21E+01	c	6.69E+01	c	2.52E-01	c	4.84E-03	9.68E-02
Chromium (Total)	9.66E+01	c	5.05E+02	c	1.34E+02	n	5.59E+00	c	1.01E+04	2.01E+05
Chrysene	1.53E+02	c	3.23E+03	c	2.31E+04	c	3.43E+01	c	9.30E+00	1.86E+02
Copper	3.13E+03	n	5.19E+04	n	1.42E+04	n	7.90E+02	n	2.78E+01	5.56E+02
Crotonaldehyde	3.66E+00	c	1.91E+01	c	1.30E+02	c	4.04E-01	c	7.11E-05	1.42E-03
Cumene (isopropylbenzene)	2.36E+03	ns	1.42E+04	ns	2.74E+03	ns	4.47E+02	n	5.69E-01	1.14E+01
Cyanide	1.12E+01	n	6.33E+01	n	1.21E+01	n	1.46E+00	n	2.61E-04	5.22E-03
Cyanogen	7.82E+01	n	1.30E+03	n	3.54E+02	n	1.99E+01	n	4.01E-03	8.01E-02
Cyanogen bromide	7.04E+03	n	1.17E+05	nl	3.19E+04	n	1.80E+03	n	5.29E-01	1.06E+01
Cyanogen chloride	3.91E+03	n	6.49E+04	n	1.77E+04	n	9.99E+02	n	2.94E-01	5.88E+00
DDD	2.22E+01	c	1.07E+02	c	7.78E+02	c	3.06E-01	c	5.39E-02	1.08E+00
DDE	1.57E+01	c	7.55E+01	c	5.49E+02	c	2.29E+00	c	4.04E-01	8.08E+00

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
DDT	1.87E+01	c	9.50E+01	c	1.62E+02	n	2.29E+00	c	5.80E-01	1.16E+01
Dibenz(a,h)anthracene	1.53E-01	c	3.23E+00	c	2.40E+01	c	1.06E-01	c	3.05E-01	6.11E+00
1,2-Dibromo-3-chloropropane	8.58E-02	c	1.18E+00	c	5.53E+00	c	3.36E-03	c	1.17E-06	2.34E-05
Dibromochloromethane	1.39E+01	c	6.74E+01	c	3.40E+02	c	1.68E+00	c	3.77E-04	7.54E-03
1,2-Dibromoethane	6.72E-01	c	3.31E+00	c	1.63E+01	c	7.46E-02	c	1.76E-05	3.52E-04
1,4-Dichloro-2-butene	1.15E-01	c	5.58E-01	c	2.59E+00	c	1.34E-02	c	5.00E-06	9.99E-05
1,2-Dichlorobenzene	2.15E+03	ns	1.30E+04	ns	2.50E+03	ns	3.02E+02	n	2.29E-01	4.58E+00
1,4-Dichlorobenzene	3.28E+01	c	1.59E+02	c	7.46E+02	c	4.81E+00	c	3.60E-03	7.20E-02
3,3-Dichlorobenzidine	1.18E+01	c	5.70E+01	c	4.10E+02	c	1.24E+00	c	6.14E-03	1.23E-01
Dichlorodifluoromethane	1.82E+02	n	8.65E+02	ns	1.61E+02	n	1.97E+02	n	3.61E-01	7.23E+00
1,1-Dichloroethane	7.86E+01	c	3.83E+02	c	1.82E+03	cs	2.75E+01	c	6.79E-03	1.36E-01
1,2-Dichloroethane	8.32E+00	c	4.07E+01	c	5.38E+01	n	1.71E+00	c	4.07E-04	8.14E-03
cis-1,2-Dichloroethene	1.56E+02	n	2.60E+03	ns	7.08E+02	n	3.65E+01	n	9.18E-03	1.84E-01
trans-1,2-Dichloroethene	2.95E+02	n	1.61E+03	ns	3.05E+02	n	9.32E+01	n	2.35E-02	4.69E-01
1,1-Dichloroethene	4.40E+02	n	2.26E+03	ns	4.24E+02	n	2.84E+02	n	9.74E-02	1.95E+00
2,4-Dichlorophenol	1.85E+02	n	2.75E+03	n	8.07E+02	n	4.53E+01	n	4.13E-02	8.25E-01
1,2-Dichloropropane	1.78E+01	c	8.68E+01	c	2.54E+01	n	4.37E+00	c	1.21E-03	2.43E-02
1,3-Dichloropropene	2.93E+01	c	1.46E+02	c	1.30E+02	n	4.70E+00	c	1.40E-03	2.80E-02
Dicyclopentadiene	1.73E+00	n	8.14E+00	n	1.51E+00	n	6.25E-01	n	1.71E-03	3.42E-02
Dieldrin	3.33E-01	c	1.60E+00	c	1.17E+01	c	1.71E-02	c	5.18E-04	1.04E-02
Diethyl phthalate	4.93E+04	n	7.33E+05	nl	2.15E+05	nl	1.48E+04	n	4.89E+00	9.79E+01
Di-n-butyl phthalate (Dibutyl phthalate)	6.16E+03	n	9.16E+04	n	2.69E+04	n	8.85E+02	n	1.69E+00	3.38E+01
2,4-Dimethylphenol	1.23E+03	n	1.83E+04	n	5.38E+03	n	3.54E+02	n	3.22E-01	6.45E+00
4,6-Dinitro-o-cresol	4.93E+00	n	7.33E+01	n	2.15E+01	n	1.51E+00	n	1.97E-03	3.94E-02
2,4-Dinitrophenol	1.23E+02	n	1.83E+03	n	5.38E+02	n	3.88E+01	n	3.35E-02	6.71E-01
2,4-Dinitrotoluene	1.71E+01	c	8.23E+01	c	5.36E+02	n	2.37E+00	c	2.46E-03	4.91E-02
2,6-Dintitrotoluene	3.56E+00	c	1.72E+01	c	8.09E+01	n	4.84E-01	c	5.10E-04	1.02E-02
2,4/2,6-Dintrotoluene Mixture	7.83E+00	c	3.77E+01	c	2.77E+02	c	1.06E+00	c	1.12E-03	2.23E-02
1,4-Dioxane	5.33E+01	c	2.57E+02	c	1.88E+03	c	7.76E+00	c	1.38E-03	2.75E-02
1,2-Diphenylhydrazine	6.66E+00	c	3.21E+01	c	2.34E+02	c	7.73E-01	c	1.88E-03	3.76E-02
Endosulfan	3.70E+02	n	5.50E+03	n	1.61E+03	n	9.87E+01	n	1.02E+00	2.04E+01
Endrin	1.85E+01	n	2.75E+02	n	8.07E+01	n	2.23E+00	n	6.77E-02	1.35E+00
Epichlorohydrin	4.27E+01	n	2.15E+02	n	4.02E+01	n	2.05E+00	n	3.86E-04	7.72E-03

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Ethyl acetate	1.82E+03	n	8.75E+03	n	1.63E+03	n	1.45E+02	n	2.64E-02	5.28E-01
Ethyl acrylate	1.45E+02	c	7.57E+02	c	5.16E+03	cs	1.56E+01	c	2.99E-03	5.97E-02
Ethyl chloride	1.90E+04	ns	8.95E+04	ns	1.66E+04	ns	2.09E+04	n	5.37E+00	1.07E+02
Ethyl ether	1.56E+04	ns	2.60E+05	nls	7.08E+04	ns	3.93E+03	n	7.60E-01	1.52E+01
Ethyl methacrylate	2.73E+03	ns	1.78E+04	ns	3.48E+03	ns	4.55E+02	n	9.15E-02	1.83E+00
Ethylbenzene	7.51E+01	c	3.68E+02	cs	1.77E+03	cs	1.49E+01	c	1.31E-02	2.62E-01
Ethylene oxide	5.02E+00	c	2.48E+01	c	1.23E+02	c	5.08E-01	c	9.09E-05	1.82E-03
Fluoranthene	2.32E+03	n	3.37E+04	n	1.00E+04	n	8.02E+02	n	6.69E+01	1.34E+03
Fluorene	2.32E+03	n	3.37E+04	n	1.00E+04	n	2.88E+02	n	4.00E+00	8.00E+01
Fluoride	4.69E+03	n	7.78E+04	n	1.81E+04	n	1.18E+03	n	1.78E+02	3.56E+03
Furan	7.24E+01	n	1.15E+03	n	3.54E+02	n	1.92E+01	n	6.12E-03	1.22E-01
Heptachlor	1.18E+00	c	5.70E+00	c	4.15E+01	c	4.39E-02	c	2.73E-03	5.45E-02
Hexachlorobenzene	3.33E+00	c	1.60E+01	c	1.17E+02	c	4.87E-01	c	4.61E-03	9.22E-02
Hexachloro-1,3-butadiene	6.16E+01	n	3.29E+02	c	2.69E+02	n	2.95E+00	c	4.39E-03	8.79E-02
Hexachlorocyclopentadiene	3.70E+02	n	5.49E+03	n	8.67E+02	n	2.78E+01	n	6.68E-02	1.34E+00
Hexachloroethane	4.31E+01	n	6.41E+02	c	1.88E+02	n	6.80E+00	n	3.31E-03	6.62E-02
n-Hexane	6.15E+02	ns	3.20E+03	ns	6.03E+02	ns	3.19E+02	n	2.78E+00	5.57E+01
HMX	3.85E+03	n	6.33E+04	n	1.74E+04	n	1.00E+03	n	9.72E-01	1.94E+01
Hydrazine anhydride	1.78E+00	c	8.55E+00	c	5.99E+01	c	2.60E-01	c	4.50E-05	9.00E-04
Hydrogen cyanide	1.02E+01	n	5.72E+01	n	1.09E+01	n	1.46E+00	n	2.61E-04	5.22E-03
Indeno(1,2,3-c,d)pyrene	1.53E+00	c	3.23E+01	c	2.40E+02	c	3.43E-01	c	1.00E+00	2.01E+01
Iron	5.48E+04	n	9.08E+05	nl	2.48E+05	nl	1.38E+04	n	3.48E+02	6.96E+03
Isobutanol (Isobutyl alcohol)	1.85E+04	n	2.75E+05	nl	8.07E+04	n	5.91E+03	n	1.05E+00	2.10E+01
Isophorone	5.61E+03	c	2.70E+04	c	5.37E+04	n	7.79E+02	c	2.11E-01	4.22E+00
Lead	4.00E+02	IEUBK	8.00E+02	IEUBK	8.00E+02	IEUBK				
Lead (tetraethyl-)	6.16E-03	n	9.16E-02	n	3.54E-02	n	1.24E-03	n	4.70E-06	9.41E-05
Maleic hydrazide	3.08E+04	n	4.58E+05	nl	1.35E+05	nl	1.00E+04	n	1.79E+00	3.57E+01
Manganese	1.05E+04	n	1.60E+05	nl	4.64E+02	n	2.02E+03	n	1.31E+02	2.63E+03
Mercury (elemental)	2.38E+01	ns	1.12E+02	ns	2.07E+01	ns	6.26E-01	n	3.27E-02	6.54E-01
Mercury (methyl)	7.82E+00	n	1.30E+02	n	3.54E+01	n	1.96E+00	n	4.45E-04	8.89E-03
Mercury (salts)	2.35E+01	n	3.89E+02	ns	7.71E+01	n	4.92E+00	n	2.56E-01	5.13E+00
Methacrylonitrile	7.70E+00	n	1.23E+02	n	3.28E+01	n	1.91E+00	n	3.71E-04	7.43E-03
Methomyl	1.54E+03	n	2.29E+04	n	6.73E+03	n	4.98E+02	n	9.37E-02	1.87E+00

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Methyl acetate	7.82E+04	ns	1.30E+06	nls	3.54E+05	nls	1.99E+04	n	3.55E+00	7.11E+01
Methyl acrylate	3.50E+02	n	1.85E+03	n	3.48E+02	n	3.90E+01	n	7.13E-03	1.43E-01
Methyl isobutyl ketone	5.81E+03	ns	8.16E+04	ns	2.02E+04	ns	1.24E+03	n	2.40E-01	4.80E+00
Methyl methacrylate	1.11E+04	ns	5.65E+04	ns	1.06E+04	ns	1.39E+03	n	2.61E-01	5.22E+00
Methyl styrene (alpha)	5.48E+03	ns	9.08E+04	ns	2.48E+04	ns	7.65E+02	n	9.43E-01	1.89E+01
Methyl styrene (mixture)	2.73E+02	ns	2.20E+03	ns	4.49E+02	ns	3.73E+01	n	4.70E-02	9.40E-01
Methylcyclohexane	5.50E+03	ns	2.59E+04	ns	4.82E+03	ns	6.26E+03	n	1.58E+01	3.16E+02
Methylene bromide (Dibromomethane)	5.79E+01	n	2.88E+02	n	5.39E+01	n	8.00E+00	n	1.68E-03	3.35E-02
Methylene chloride	4.09E+02	n	5.13E+03	ns	1.21E+03	n	1.06E+02	n	2.35E-02	4.71E-01
Molybdenum	3.91E+02	n	6.49E+03	n	1.77E+03	n	9.87E+01	n	1.99E+00	3.98E+01
Naphthalene	4.97E+01	c	2.41E+02	c	1.59E+02	n	1.65E+00	c	4.11E-03	8.23E-02
Nickel	1.56E+03	n	2.57E+04	n	7.53E+02	n	3.72E+02	n	2.42E+01	4.85E+02
Nitrate	1.25E+05	nl	2.08E+06	nl	5.66E+05	nl	3.16E+04	n	2.13E+01	4.25E+02
Nitrite	7.82E+03	n	1.30E+05	nl	3.54E+04	n	1.97E+03	n	1.33E+00	2.66E+01
Nitrobenzene	6.04E+01	c	2.93E+02	c	3.53E+02	n	1.40E+00	c	7.20E-04	1.44E-02
Nitroglycerin	6.16E+00	n	9.16E+01	n	2.69E+01	n	1.96E+00	n	6.80E-04	1.36E-02
N-Nitrosodiethylamine	7.94E-03	c	1.71E-01	c	1.25E+00	c	1.65E-03	c	4.92E-07	9.84E-06
N-Nitrosodimethylamine	2.34E-02	c	5.03E-01	c	2.14E+00	n	4.90E-03	c	1.02E-06	2.03E-05
N-Nitrosodi-n-butylamine	7.81E-01	c	3.77E+00	c	2.46E+01	c	2.72E-02	c	4.21E-05	8.41E-04
N-Nitrosodiphenylamine	1.09E+03	c	5.24E+03	c	3.79E+04	c	1.21E+02	c	4.98E-01	9.95E+00
N-Nitrosopyrrolidine	2.54E+00	c	1.22E+01	c	8.89E+01	c	3.70E-01	c	1.15E-04	2.30E-03
m-Nitrotoluene	6.16E+00	n	9.16E+01	n	2.69E+01	n	1.74E+00	n	1.25E-03	2.50E-02
o-Nitrotoluene	3.16E+01	c	1.65E+02	c	3.19E+02	n	3.13E+00	c	2.28E-03	4.56E-02
p-Nitrotoluene	2.47E+02	n	1.60E+03	c	1.08E+03	n	4.24E+01	c	3.05E-02	6.09E-01
Pentachlorobenzene	4.93E+01	n	7.33E+02	n	2.15E+02	n	3.07E+00	n	1.76E-02	3.52E-01
Pentachlorophenol	9.85E+00	c	4.45E+01	c	3.46E+02	c	4.00E-01	c	3.04E-03	6.08E-02
Perchlorate	5.48E+01	n	9.08E+02	ns	2.48E+02	n	1.38E+01	n	5.85E-03	1.17E-01
Phenanthrene	1.74E+03	n	2.53E+04	n	7.53E+03	n	1.70E+02	n	4.30E+00	8.59E+01
Phenol	1.85E+04	n	2.75E+05	nl	7.74E+04	n	5.76E+03	n	2.62E+00	5.23E+01
Polychlorinatedbiphenyls (PCBs)										
Aroclor 1016	3.98E+00	n	5.74E+01	n	1.72E+01	n	1.40E+00	n	1.01E-01	2.01E+00
Aroclor 1221	1.81E+00	c	8.57E+00	c	5.53E+01	cs	5.54E-02	c	7.08E-04	1.42E-02
Aroclor 1232	1.86E+00	c	8.82E+00	c	5.76E+01	cs	5.54E-02	c	7.08E-04	1.42E-02

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Aroclor 1242	2.43E+00	c	1.15E+01	c	8.53E+01	c	3.89E-01	c	4.57E-02	9.14E-01
Aroclor 1248	2.43E+00	c	1.15E+01	c	8.53E+01	c	3.89E-01	c	4.48E-02	8.96E-01
Aroclor 1254	1.14E+00	n	1.15E+01	c	4.91E+00	n	3.89E-01	c	7.63E-02	1.53E+00
Aroclor 1260	2.43E+00	c	1.15E+01	c	8.53E+01	c	3.89E-01	c	2.04E-01	4.09E+00
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	3.75E-01	c	1.77E+00	c	1.72E+00	n	5.99E-02	c	3.21E-02	6.42E-01
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	3.75E+00	c	1.77E+01	c	1.72E+01	n	5.99E-01	c	3.14E-01	6.29E+00
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	1.05E-01	2.10E+00
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	6.27E-02	1.25E+00
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	6.40E-02	1.28E+00
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	6.40E-02	1.28E+00
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	1.25E-03	c	5.89E-03	c	5.73E-03	n	2.00E-04	c	6.27E-05	1.25E-03
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	3.91E-02	7.83E-01
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	3.84E-02	7.67E-01
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	3.91E-02	7.83E-01
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	3.91E-02	7.83E-01
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	3.75E-04	c	1.77E-03	c	1.72E-03	n	5.99E-05	c	1.15E-05	2.30E-04
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	3.75E-01	c	1.77E+00	c	1.72E+00	n	5.99E-02	c	7.03E-03	1.41E-01
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	1.25E-01	c	5.89E-01	c	5.73E-01	n	2.00E-02	c	2.34E-03	4.69E-02
Propylene oxide	2.56E+01	c	1.33E+02	c	7.99E+02	n	2.66E+00	c	4.82E-04	9.65E-03
Pyrene	1.74E+03	n	2.53E+04	n	7.53E+03	n	1.17E+02	n	9.59E+00	1.92E+02
RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine	6.04E+01	c	3.11E+02	c	1.01E+03	n	7.02E+00	c	2.16E-03	4.31E-02
Selenium	3.91E+02	n	6.49E+03	n	1.75E+03	n	9.87E+01	n	5.11E-01	1.02E+01
Silver	3.91E+02	n	6.49E+03	n	1.77E+03	n	8.12E+01	n	6.88E-01	1.38E+01
Strontium	4.69E+04	n	7.79E+05	nl	2.12E+05	nl	1.18E+04	n	4.17E+02	8.33E+03
Styrene	7.26E+03	ns	5.13E+04	ns	1.02E+04	ns	1.21E+03	n	1.03E+00	2.06E+01
Sulfolane	6.16E+01	n	9.16E+02	n	2.65E+02	n	2.00E+01	n	3.75E-03	7.49E-02
2,3,7,8-TCDD	4.90E-05	c	2.48E-04	c	2.26E-04	n	5.99E-06	c	2.24E-06	4.48E-05
2,3,7,8-TCDF	4.90E-04	c	2.48E-03	c	1.72E-02	c	2.01E-06	c	4.22E-07	8.44E-06
1,2,4,5-Tetrachlorobenzene	1.85E+01	n	2.75E+02	n	8.07E+01	n	1.66E+00	n	5.83E-03	1.17E-01
1,1,1,2-Tetrachloroethane	2.81E+01	c	1.37E+02	c	6.59E+02	cs	5.72E+00	c	1.80E-03	3.59E-02
1,1,2,2-Tetrachloroethane	7.98E+00	c	3.94E+01	c	1.97E+02	c	7.57E-01	c	2.40E-04	4.80E-03
Tetrachloroethene	1.11E+02	ns	6.29E+02	ns	1.20E+02	ns	4.03E+01	n	1.60E-02	3.21E-01
Tetryl (Trinitrophenylmethylnitramine)	1.56E+02	n	2.59E+03	n	7.06E+02	n	3.94E+01	n	2.79E-01	5.59E+00

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
Thallium	7.82E-01	n	1.30E+01	n	3.54E+00	n	1.97E-01	n	1.41E-02	2.81E-01
Toluene	5.23E+03	ns	6.13E+04	ns	1.40E+04	ns	1.09E+03	n	6.07E-01	1.21E+01
Toxaphene	4.84E+00	c	2.33E+01	c	1.70E+02	c	1.53E-01	c	1.77E-02	3.54E-01
Tribromomethane (Bromoform)	6.74E+02	c	3.25E+03	c	5.38E+03	n	9.19E+01	c	2.05E-02	4.11E-01
1,1,2-Trichloro-1,2,2-trifluoroethane	5.08E+04	ns	2.43E+05	nls	4.53E+04	ns	5.50E+04	n	1.60E+02	3.20E+03
1,2,4-Trichlorobenzene	8.29E+01	n	4.23E+02	ns	7.91E+01	n	3.98E+00	n	8.82E-03	1.76E-01
1,1,1-Trichloroethane	1.44E+04	ns	7.25E+04	ns	1.36E+04	ns	8.00E+03	n	2.55E+00	5.11E+01
1,1,2-Trichloroethane	2.61E+00	n	1.24E+01	n	2.30E+00	n	4.15E-01	n	1.11E-04	2.23E-03
Trichloroethylene	6.77E+00	n	3.65E+01	n	6.90E+00	n	2.82E+00	n	8.75E-04	1.75E-02
Trichlorofluoromethane	1.23E+03	ns	6.03E+03	ns	1.13E+03	ns	1.14E+03	n	7.84E-01	1.57E+01
2,4,5-Trichlorophenol	6.16E+03	n	9.16E+04	n	2.69E+04	n	1.17E+03	n	3.31E+00	6.62E+01
2,4,6-Trichlorophenol	6.16E+01	n	9.16E+02	n	2.69E+02	n	1.19E+01	n	3.37E-02	6.74E-01
1,1,2-Trichloropropane	3.91E+02	n	6.49E+03	ns	1.77E+03	ns	8.81E+01	n	2.79E-02	5.59E-01
1,2,3-Trichloropropane	5.10E-02	c	1.21E+00	c	6.31E+00	n	7.47E-03	c	2.60E-06	5.21E-05
Triethylamine	1.93E+02	n	9.09E+02	n	1.69E+02	n	1.46E+01	n	3.65E-03	7.31E-02
2,4,6-Trinitrotoluene	3.60E+01	n	5.73E+02	n	1.61E+02	n	9.80E+00	n	4.30E-02	8.61E-01
Uranium (soluable salts)	2.34E+02	n	3.88E+03	ns	2.77E+02	ns	5.92E+01	n	2.67E+01	5.33E+02
Vanadium	3.94E+02	n	6.53E+03	n	6.14E+02	n	6.31E+01	n	6.31E+01	1.26E+03
Vinyl acetate	2.56E+03	n	1.24E+04	ns	2.30E+03	ns	4.09E+02	n	7.52E-02	1.50E+00
Vinyl bromide	2.71E+00	c	1.31E+01	c	8.46E+00	n	1.75E+00	c	4.62E-04	9.23E-03
Vinyl chloride	7.42E-01	c	2.84E+01	c	1.61E+02	c	2.01E-01	c	6.75E-05	1.35E-03
m-Xylene	7.64E+02	ns	3.73E+03	ns	6.96E+02	ns	1.93E+02	n	1.48E-01	2.97E+00
o-Xylene	8.05E+02	ns	3.94E+03	ns	7.36E+02	ns	1.93E+02	n	1.49E-01	2.98E+00
Xylenes	8.71E+02	ns	4.28E+03	ns	7.98E+02	ns	1.93E+02	n	1.49E-01	2.98E+00
Zinc	2.35E+04	n	3.89E+05	nl	1.06E+05	nl	5.96E+03	n	3.71E+02	7.41E+03

c – carcinogen
cs - carcinogenic, SSL may exceed saturation
DAF – Dilution Attenuation Factor
mg/kg – milligrams per kilogram
n – noncarcinogenic
nl - noncarcinogen, SSL may exceed ceiling limit
ns - noncarcinogen, SSL may exceed saturation
nls - noncarcinogen, SSL may exceed both saturation and ceiling limit
SSL – Soil Screening Level
µg/L – micrograms per liter

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, 2014
	-- child resident	200	US EPA, 2014
	-- 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. NMED Vapor Intrusion Screening Levels (VISLs)

Chemical	Residential Indoor Air (µg/m^3)	Endpoint	Residential Soil-gas (µg/m^3)	Residential Groundwater (µg/L)	Industrial/ Occupational Indoor Air (µg/m^3)	Endpoint	Industrial/ OccupationalSoil -gas (µg/m^3)	Industrial/ Occupational Groundwater (µg/L)
Acetaldehyde	9.39E+00	n	9.39E+01	3.43E+03	4.42E+01	n	4.42E+02	1.62E+04
Acetone	3.23E+04	n	3.23E+05	2.25E+07	1.52E+05	n	1.52E+06	1.06E+08
Acrylonitrile	4.13E-01	c	4.13E+00	7.30E+01	2.02E+00	c	2.02E+01	3.58E+02
Acrolein	2.09E-02	n	2.09E-01	4.17E+00	9.83E-02	n	9.83E-01	1.97E+01
Benzene	3.60E+00	c	3.60E+01	1.58E+01	1.76E+01	c	1.76E+02	7.76E+01
1,1-Biphenyl	4.17E-01	n	4.17E+00	3.30E+01	1.97E+00	n	1.97E+01	1.56E+02
Bis(2-chloroethyl) ether	8.51E-02	c	8.51E-01	1.22E+02	4.17E-01	c	4.17E+00	5.98E+02
Bis(chloromethyl) ether	4.53E-04	c	4.53E-03	2.53E-03	2.22E-03	c	2.22E-02	1.24E-02
Bromodichloromethane	7.59E-01	c	7.59E+00	8.73E+00	3.72E+00	c	3.72E+01	4.28E+01
Bromomethane	5.21E+00	n	5.21E+01	1.73E+01	2.46E+01	n	2.46E+02	8.17E+01
1,3-Butadiene	9.36E-01	c	9.36E+00	3.10E-01	4.59E+00	c	4.59E+01	1.52E+00
2-Butanone (Methyl ethyl ketone, MEK)	5.21E+03	n	5.21E+04	2.24E+06	2.46E+04	n	2.46E+05	1.05E+07
tert-Butyl methyl ether (MTBE)	1.08E+02	c	1.08E+03	4.49E+03	5.29E+02	c	5.29E+03	2.20E+04
Carbon disulfide	7.30E+02	n	7.30E+03	1.24E+03	3.44E+03	n	3.44E+04	5.83E+03
Carbon tetrachloride	4.68E+00	c	4.68E+01	4.14E+00	2.29E+01	c	2.29E+02	2.03E+01
2-Chloro-1,3-butadiene	9.36E-02	c	9.36E-01	4.07E-02	4.59E-01	c	4.59E+00	1.99E-01
1-Chloro-1,1-difluoroethane	5.21E+04	n	5.21E+05	2.16E+04	2.46E+05	n	2.46E+06	1.02E+05
Chlorobenzene	5.21E+01	n	5.21E+02	4.09E+02	2.46E+02	n	2.46E+03	1.93E+03
Chlorodifluoromethane	5.21E+04	n	5.21E+05	3.13E+04	2.46E+05	n	2.46E+06	1.48E+05
Chloroform	1.22E+00	c	1.22E+01	8.11E+00	5.98E+00	c	5.98E+01	3.98E+01
Chloromethane	1.56E+01	c	1.56E+02	4.31E+01	7.65E+01	c	7.65E+02	2.11E+02

Chemical	Residential Indoor Air (µg/m^3)	Endpoint	Residential Soil-gas (µg/m^3)	Residential Groundwater (µg/L)	Industrial/ Occupational Indoor Air (µg/m^3)	Endpoint	Industrial/ OccupationalSoil -gas (µg/m^3)	Industrial/ Occupational Groundwater (µg/L)
2-Chloropropane	1.04E+02	n	1.04E+03	1.45E+02	4.92E+02	n	4.92E+03	6.85E+02
Cumene (isopropylbenzene)	4.17E+02	n	4.17E+03	8.85E+02	1.97E+03	n	1.97E+04	4.17E+03
Cyanide	8.34E-01	n	8.34E+00	1.53E+02	3.93E+00	n	3.93E+01	7.21E+02
1,2-Dibromo-3-chloropropane	1.69E-03	c	1.69E-02	2.80E-01	2.29E-02	c	2.29E-01	3.81E+00
Dibromochloromethane	1.04E+00	c	1.04E+01	3.24E+01	5.10E+00	c	5.10E+01	1.59E+02
1,2-Dibromoethane	4.68E-02	c	4.68E-01	1.76E+00	2.29E-01	c	2.29E+00	8.61E+00
1,4-Dichloro-2-butene	6.68E-03	c	6.68E-02	2.46E-01	3.28E-02	c	3.28E-01	1.20E+00
1,2-Dichlorobenzene	2.09E+02	n	2.09E+03	2.65E+03	9.83E+02	n	9.83E+03	1.25E+04
1,4-Dichlorobenzene	2.55E+00	c	2.55E+01	2.58E+01	1.25E+01	c	1.25E+02	1.27E+02
Dichlorodifluoromethane	1.04E+02	n	1.04E+03	7.42E+00	4.92E+02	n	4.92E+03	3.50E+01
1,1-Dichloroethane	1.75E+01	c	1.75E+02	7.62E+01	8.60E+01	c	8.60E+02	3.73E+02
1,2-Dichloroethane	1.08E+00	c	1.08E+01	2.23E+01	5.29E+00	c	5.29E+01	1.09E+02
trans-1,2-Dichloroethene	6.26E+01	n	6.26E+02	3.74E+02	2.95E+02	n	2.95E+03	1.76E+03
1,1-Dichloroethene	2.09E+02	n	2.09E+03	1.95E+02	9.83E+02	n	9.83E+03	9.19E+02
1,2-Dichloropropane	2.81E+00	c	2.81E+01	2.43E+01	1.38E+01	c	1.38E+02	1.19E+02
1,3-Dichloropropene	7.02E+00	c	7.02E+01	4.82E+01	3.44E+01	c	3.44E+02	2.36E+02
Dicyclopentadiene	3.13E-01	n	3.13E+00	1.22E-01	1.47E+00	n	1.47E+01	5.76E-01
Epichlorohydrin	1.04E+00	n	1.04E+01	8.37E+02	4.92E+00	n	4.92E+01	3.94E+03
Ethyl acetate	7.30E+01	n	7.30E+02	1.33E+04	3.44E+02	n	3.44E+03	6.26E+04
Ethyl chloride	1.04E+04	n	1.04E+05	2.29E+04	4.92E+04	n	4.92E+05	1.08E+05
Ethyl methacrylate	3.13E+02	n	3.13E+03	1.33E+04	1.47E+03	n	1.47E+04	6.28E+04
Ethylbenzene	1.12E+01	c	1.12E+02	3.48E+01	5.51E+01	c	5.51E+02	1.70E+02
Ethylene oxide	3.19E-01	c	3.19E+00	5.26E+01	1.56E+00	c	1.56E+01	2.58E+02
n-Hexane	7.30E+02	n	7.30E+03	9.89E+00	3.44E+03	n	3.44E+04	4.66E+01
Hydrogen cyanide	8.34E-01	n	8.34E+00	1.53E+02	3.93E+00	n	3.93E+01	7.21E+02

Chemical	Residential Indoor Air (µg/m^3)	Endpoint	Residential Soil-gas (µg/m^3)	Residential Groundwater (µg/L)	Industrial/ Occupational Indoor Air (µg/m^3)	Endpoint	Industrial/ OccupationalSoil -gas (µg/m^3)	Industrial/ Occupational Groundwater (µg/L)
Mercury (elemental)	3.13E-01	n	3.13E+00	6.69E-01	1.47E+00	n	1.47E+01	3.16E+00
Methacrylonitrile	3.13E+01	n	3.13E+02	3.09E+03	1.47E+02	n	1.47E+03	1.46E+04
Methyl acrylate	2.09E+01	n	2.09E+02	2.56E+03	9.83E+01	n	9.83E+02	1.21E+04
Methyl isobutyl ketone	3.13E+03	n	3.13E+04	5.53E+05	1.47E+04	n	1.47E+05	2.61E+06
Methyl methacrylate	7.30E+02	n	7.30E+03	5.58E+04	3.44E+03	n	3.44E+04	2.63E+05
Methyl styrene (mixture)	4.17E+01	n	4.17E+02	3.34E+02	1.97E+02	n	1.97E+03	1.57E+03
Methylcyclohexane	3.13E+03	n	3.13E+04	1.77E+02	1.47E+04	n	1.47E+05	8.36E+02
Methylene bromide (Dibromomethane)	4.17E+00	n	4.17E+01	1.24E+02	1.97E+01	n	1.97E+02	5.83E+02
Methylene chloride	6.26E+02	n	6.26E+03	4.70E+03	2.95E+03	n	2.95E+04	2.21E+04
Naphthalene	8.26E-01	c	8.26E+00	4.58E+01	4.05E+00	c	4.05E+01	2.24E+02
Nitrobenzene	7.02E-01	c	7.02E+00	7.13E+02	3.44E+00	c	3.44E+01	3.50E+03
N-Nitrosodi-n-butylamine	1.75E-02	c	1.75E-01	3.24E+01	8.60E-02	c	8.60E-01	1.59E+02
Aroclor 1221	4.93E-02	c	4.93E-01	1.63E+00	2.41E-01	c	2.41E+00	8.00E+00
Aroclor 1232	4.93E-02	c	4.93E-01	1.63E+00	2.41E-01	c	2.41E+00	8.00E+00
Propylene oxide	7.59E+00	c	7.59E+01	2.66E+03	3.72E+01	c	3.72E+02	1.30E+04
Styrene	1.04E+03	n	1.04E+04	9.25E+03	4.92E+03	n	4.92E+04	4.36E+04
1,1,1,2-Tetrachloroethane	3.79E+00	c	3.79E+01	3.70E+01	1.86E+01	c	1.86E+02	1.81E+02
1,1,2,2-Tetrachloroethane	4.84E-01	c	4.84E+00	3.22E+01	2.37E+00	c	2.37E+01	1.58E+02
Tetrachloroethene	4.17E+01	n	4.17E+02	5.75E+01	1.97E+02	n	1.97E+03	2.71E+02
Toluene	5.21E+03	n	5.21E+04	1.92E+04	2.46E+04	n	2.46E+05	9.03E+04
1,1,2-Trichloro-1,2,2-trifluoroethane	3.13E+04	n	3.13E+05	1.45E+03	1.47E+05	n	1.47E+06	6.84E+03
1,2,4-Trichlorobenzene	2.09E+00	n	2.09E+01	3.58E+01	9.83E+00	n	9.83E+01	1.69E+02
1,1,1-Trichloroethane	5.21E+03	n	5.21E+04	7.39E+03	2.46E+04	n	2.46E+05	3.49E+04
1,1,2-Trichloroethane	2.09E-01	n	2.09E+00	6.17E+00	9.83E-01	n	9.83E+00	2.91E+01
Trichloroethylene	2.09E+00	n	2.09E+01	5.16E+00	9.83E+00	n	9.83E+01	2.43E+01

Chemical	Residential Indoor Air (µg/m^3)	Endpoint	Residential Soil-gas (µg/m^3)	Residential Groundwater (µg/L)	Industrial/ Occupational Indoor Air (µg/m^3)	Endpoint	Industrial/ OccupationalSoil -gas (µg/m^3)	Industrial/ Occupational Groundwater (µg/L)
Trichlorofluoromethane	7.30E+02	n	7.30E+03	1.84E+02	3.44E+03	n	3.44E+04	8.65E+02
1,2,3-Trichloropropane	3.13E-01	n	3.13E+00	2.22E+01	1.47E+00	n	1.47E+01	1.05E+02
Triethylamine	7.30E+00	n	7.30E+01	1.19E+03	3.44E+01	n	3.44E+02	5.63E+03
Vinyl acetate	2.09E+02	n	2.09E+03	9.96E+03	9.83E+02	n	9.83E+03	4.69E+04
Vinyl bromide	8.77E-01	c	8.77E+00	1.74E+00	4.30E+00	c	4.30E+01	8.53E+00
Vinyl chloride	1.68E+00	c	1.68E+01	1.47E+00	3.13E+01	c	3.13E+02	2.74E+01
m-Xylene	1.04E+02	n	1.04E+03	3.54E+02	4.92E+02	n	4.92E+03	1.67E+03
o-Xylene	1.04E+02	n	1.04E+03	4.91E+02	4.92E+02	n	4.92E+03	2.31E+03
Xylenes	1.04E+02	n	1.04E+03	4.91E+02	4.92E+02	n	4.92E+03	2.31E+03

APPENDIX B

CHEMICAL AND PHYSICAL PROPERTIES

Table B-1: Chemical CAS and Molecular Weight

Chemical	Chemical Abstracts Service (CAS) Registry Number	Molecular Weight (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
Acrylonitrile	107-13-1	53.06	EPI
Acetophenone	98-86-2	120.15	EPI
Acrolein	107-02-8	56.06	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
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
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

Chemical	Chemical Abstracts Service (CAS) Registry Number	Molecular Weight (MW) (g/mole)	Ref.
Cadmium	7440-43-9	112.41	P
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
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

Chemical	Chemical Abstracts Service (CAS) Registry Number	Molecular Weight (MW) (g/mole)	Ref.
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
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
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

Chemical	Chemical Abstracts Service (CAS) Registry Number	Molecular Weight (MW) (g/mole)	Ref.
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
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
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

Chemical	Chemical Abstracts Service (CAS) Registry Number	Molecular Weight (MW) (g/mole)	Ref.
Methylene chloride	75-09-2	84.93	EPI
Molybdenum	7439-98-7	95.96	P
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
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	ToxNet
Phenanthrene	85-01-8	178.24	EPI
Phenol	108-95-2	94.11	EPI
Polychlorinatedbiphenyls (PCBs)			
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
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

Chemical	Chemical Abstracts Service (CAS) Registry Number	Molecular Weight (MW) (g/mole)	Ref.
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
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
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

Chemical	Chemical Abstracts Service (CAS) Registry Number	Molecular Weight (MW) (g/mole)	Ref.
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
Xylenes	1330-20-7	106.17	EPI
Zinc	7440-66-6	65.38	P

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

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)	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	1.77E+05	3.66E+04		1
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	1
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	1
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	1
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	1
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	1
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	5.73E+05	1.18E+05		1
Antimony										4.50E+01	SSG							
Arsenic										2.90E+01	SSG							
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	1
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	1.52E+05	3.13E+04		1
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	1
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	1
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	1
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	1
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
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	1
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	1
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	1
Cadmium										7.50E+01	SSG							

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)	Soil SAT (mg/kg)	VOC
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	1
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	1
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
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	1
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
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	1
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	1
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	1
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	1
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	9.53E+04	1.97E+04		1
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	1
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	1
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	1
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				
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	1
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	1
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	1
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	3.42E+03	7.07E+02		1
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	2.52E+03	5.21E+02		1
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	1.90E+03	3.92E+02		1
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				
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				
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	1
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
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
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

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)	Soil SAT (mg/kg)	VOC
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
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	1.32E+04	2.72E+03		1
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
1,1-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
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	1
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	1
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
1,1-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	1
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
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	1
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	5.52E+03	1.14E+03		1
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				
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	1
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	1
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	1
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	1
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	1
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	1
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	1
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	1
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	3.28E+05	6.77E+04		1

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)	Soil SAT (mg/kg)	VOC
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	1
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				
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				
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	1
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								1.60E-02	EPI	2.39E-05	CALC							
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	1
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	6.24E+04	1.29E+04		1
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				
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	1
Mercury (methyl)	7.22E-03	EPI	2.96E-01	2.40E-02	W9	6.04E-06	W9	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	1
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	1
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	1
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	1
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	1
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	1
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	1
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	1
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	1
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
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	6.01E+04	1.24E+04		1
Nickel										6.50E+01	SSG							

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)	Soil SAT (mg/kg)	VOC
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	1
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				
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		1
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	1
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				
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							
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	6.47E+05	1.34E+05		1
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				
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	1
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	1
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				
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				
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				
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				
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				
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				
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				
2,3,3',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				
2,3,3',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				
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',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				
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				

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)	Soil SAT (mg/kg)	VOC
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				
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				
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				
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				
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	1
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	1.73E+06	3.58E+05		1
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							
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	1
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				
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				
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				
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
1,1,2,2-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	1
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	1
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	1
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				
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
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
1,1,1-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
1,1,2-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	1
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	1
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	1
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
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	1
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	1
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				

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)	Soil SAT (mg/kg)	VOC
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	1
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	1
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	1
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	1
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	1
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	1
Zinc										6.20E+01	SSG							

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	
Acrylonitrile	107-13-1	53.06	EPI	1.16E-03	EPI	1	E	2.08E-01	3.25E-03	3.05E-01	3.36E-01	5.00E-01	1.74E-04	9.48E-02	
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	
Acrolein	107-02-8	56.06	EPI	7.48E-04	EPI	1	E	2.16E-01	2.15E-03	3.05E-01	3.35E-01	5.19E-01		1.19E-03	
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	5.47E-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	6.26E-05	7.11E-04	
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	1.71E-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	4.08E-07	7.11E-03	1.32E-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	1.29E-04		4.16E-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	1.29E-05		4.16E-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	1.29E-04		4.16E-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	1.29E-03		4.16E-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	1.49E-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	5.22E-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	8.53E-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	1.14E-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	8.53E-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	1.34E-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	6.71E-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	4.27E-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	1.51E-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	
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	2.76E-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	5.22E-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	

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
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	1.34E-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	2.68E-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	4.94E-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	7.22E-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	3.13E-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	1.49E-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	4.69E-06	1.78E-04	1.52E-06
Chromium (Total)		52	P	1.00E-03	E	1	E	2.05E-01	2.77E-03	3.05E-01	3.35E-01	4.93E-01	1.71E-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	1.29E-02		4.16E-03
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	4.94E-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	
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	3.91E-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	2.76E-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	2.76E-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	1.29E-05		4.16E-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	1.17E-04	4.74E-04	3.79E-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	1.12E-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	4.69E-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			

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
1,2-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	1.74E-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	2.09E-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	1.65E-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	1.03E-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	2.61E-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	9.39E-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	5.87E-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	534-52-1	198.14	EPI	3.15E-03	EPI	1	E	1.35E+00	1.71E-02	3.14E-01	3.45E-01	3.24E+00		1.90E-04	
2,4-Dinitrophenol	51-28-5	184.11	EPI	1.87E-03	EPI	1	E	1.13E+00	9.76E-03	3.09E-01	3.40E-01	2.71E+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	3.03E-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	6.26E-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	1.38E-04		
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	9.39E-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	1.17E-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	9.48E-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	1.96E-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	8.53E-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	3.03E-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	

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
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	
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	2.09E-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	5.87E-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	1.20E-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	2.35E-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	3.13E-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	1.29E-04		4.16E-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	9.88E-02	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	
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	4.69E-02	1.42E-02	1.52E-02
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	

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
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	5.52E-03	2.37E-04	
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	6.26E-07		2.02E-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	1.84E-06	1.90E-05	5.95E-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	1.74E-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	1.92E-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	4.47E-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	4.27E-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	5.87E-03	9.48E-03	
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	2.35E-04	1.19E-02	
Perchlorate	14797-73-0	99.45	EPI	1.00E-03	E	1	E	3.79E-01	3.84E-03	3.06E-01	3.36E-01	9.08E-01		1.66E-03	
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															
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	1.34E-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	4.69E-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	4.69E-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	4.69E-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	4.69E-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	4.69E-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	4.69E-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	7.22E-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	7.22E-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	2.41E-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	2.41E-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	2.41E-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	2.41E-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	2.41E-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	2.41E-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	2.41E-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	2.41E-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	2.41E-05	5.53E-05	

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
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	7.22E-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	7.22E-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	2.41E-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	3.91E-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	
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	8.53E-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	
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	7.22E-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	7.22E-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	3.61E-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	4.69E-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	4.47E-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	8.53E-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	1.19E-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	3.24E-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	1.65E-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	2.04E-03	1.19E-03	4.36E-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	8.53E-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	3.13E-06	9.48E-03	1.01E-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	3.13E-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	

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 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	
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	1.30E-04	7.11E-03	3.06E+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	
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	

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.

APPENDIX C

TOXICITY DATA

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

Chemical	SF_o (mg/kg-day)$^{-1}$	Ref.	IUR (ug/m^3)$^{-1}$	Ref.	RfD_o (mg/kg-day)	Ref.	RfCi (mg/m^3)	Ref.	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		
Acrylonitrile	5.40E-01	IRIS	6.80E-05	IRIS	4.00E-02	ATSDR	2.00E-03	IRIS		1	E		
Acetophenone					1.00E-01	IRIS				1	E		
Acrolein					5.00E-04	IRIS	2.00E-05	IRIS		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	1.50E+00	IRIS	4.30E-03	IRIS	3.00E-04	IRIS	1.50E-05	CalEPA		1	E	0.03	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	7.30E+00	IRIS	1.10E-03	CalEPA					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		
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		

Chemical	SF_o (mg/kg-day)$^{-1}$	Ref.	IUR (ug/m^3)$^{-1}$	Ref.	RfD_o (mg/kg-day)	Ref.	RfCi (mg/m^3)	Ref.	Mutagen	GIABS	Ref.	Dermal ABS	Ref.
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
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	IRIS	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, adjusted	1.20E-02	IRIS	1.29E+00	IRIS, adjusted	1.43E-05	IRIS, adjusted		0.013	E		
Chrysene	7.30E-03	EPA TEF	1.10E-05	CalEPA					M	1	E	0.13	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
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

Chemical	SF_o (mg/kg-day)$^{-1}$	Ref.	IUR (ug/m^3)$^{-1}$	Ref.	RfD_o (mg/kg-day)	Ref.	RfCi (mg/m^3)	Ref.	Mutagen	GIABS	Ref.	Dermal ABS	Ref.
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-2	PPRTV	3.00E-4	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
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		
Ethyl chloride							1.00E+01	IRIS		1	E		

Chemical	SF_o (mg/kg-day)$^{-1}$	Ref.	IUR (ug/m^3)$^{-1}$	Ref.	RfD_o (mg/kg-day)	Ref.	RfCi (mg/m^3)	Ref.	Mutagen	GIABS	Ref.	Dermal ABS	Ref.
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	8.80E-05	CalEPA			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	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	E
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		

Chemical	SF_o (mg/kg-day)$^{-1}$	Ref.	IUR (ug/m^3)$^{-1}$	Ref.	RfD_o (mg/kg-day)	Ref.	RfCi (mg/m^3)	Ref.	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		
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
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		
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													
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
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

Chemical	SF_o (mg/kg-day)$^{-1}$	Ref.	IUR (ug/m^3)$^{-1}$	Ref.	RfD_o (mg/kg-day)	Ref.	RfCi (mg/m^3)	Ref.	Mutagen	GIABS	Ref.	Dermal ABS	Ref.
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		
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		
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		

Chemical	SF_o (mg/kg-day)$^{-1}$	Ref.	IUR (ug/m^3)$^{-1}$	Ref.	RfD_o (mg/kg-day)	Ref.	RfCi (mg/m^3)	Ref.	Mutagen	GIABS	Ref.	Dermal ABS	Ref.
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		
Xylenes					2.00E-01	IRIS	1.00E-01	IRIS		1	E		
Zinc					3.00E-01	IRIS				1	E		

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

-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[3]

July 2014

[3]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.

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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.

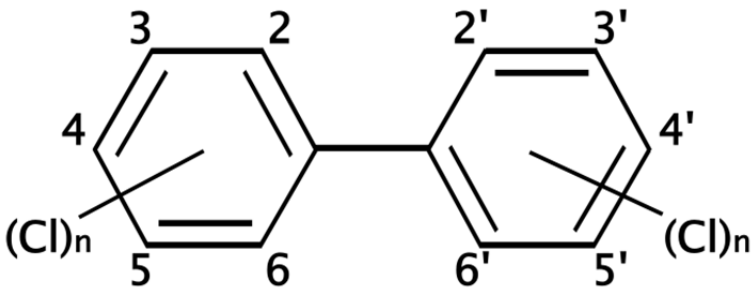
This paper **does not** discuss the risk posed to ground water quality by PCB contamination; state ground water standards and federal drinking water standards[4] exist for the protection of ground water. No state or federal soil/sediment standards exist to protect ground water from the transport of PCBs 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:

[4]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 1 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*[5] 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, 2014). Recent studies have indicated that all PCB mixtures can cause

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

cancer; however, different mixtures exhibit different carcinogenic potencies (Cogliano, 1998). 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[6];
- 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*[7], 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.

[6]The concentration of PCDFs in commercial PCB samples ranged from 0.2 mircrograms 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.

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

The highly chlorinated Aroclors (Aroclor 1248, 1254, and 1260) resist both chemical and biological transformation (i.e., degradation) in the environment. Biological degradation of highly chlorinated Aroclors to lower chlorinated PCBs can occur under anaerobic conditions[8]. The extent of this dechlorination[9] 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*[10]), 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*[11] 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.

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

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

[10]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.

[11]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 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.

Table D-1. PCB Cleanup Options In Soil/Sediment and Data Quality Recommendations[12]

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[13]. 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.

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

[13]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	50-100 µg/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[14] (unfiltered water) to a *water of the State*.[15] 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[16] 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*[17].

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.

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[14]This concentration is the Clean Water Act §304(a) recommended chronic criterion for aquatic life (http://water.epa.gov/scitech/swguidance/standards/current/index.cfm).

[15]*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).

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

[17]*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).

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:

- 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, 1997d), 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*[18] (**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[19] (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).

[18]*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..."

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

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 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 non-carcinogenic adverse human health effects, separate risk assessments must be performed for each of these health effects.

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*[20] 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.

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) 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.

[20] *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).

Table D-4. PCB Cancer Slope Factor Values by Level of Risk and Persistence[21]

CRITERIA FOR USE	LEVEL OF RISK AND PERSISTENCE	PCB CANCER SLOPE FACTOR VALUES[22] [risk per mg/kg-day]
Food chain exposure	High	2.0
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	0.4
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	0.07

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 (2.0 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,

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

[22]See IRIS (US EPA, 2014).

exposure to dioxin-like, tumor-promoting or persistent congeners, and early-life exposure) where environmental processes act to increase risk.

A lower slope factor (0.4 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 (0.07 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)[23]

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.

[23]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**[24]
CANCER SLOPE FACTORS[25] **(mg/kg-day)$^{-1}$**	. . . **greater than 0.5%** of the total PCBs present	1.3E+05[26]	2.0
	. . . **less than 0.5%** of the total PCBs present	NA[27]	0.07
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 0.4 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[28] 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).

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

[25]PCB cancer slope factors can be found in IRIS (US EPA, 2014).

[26]US EPA, 2014

[27]*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.

[28]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.

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).

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[29]

7.1.2 Non-Carcinogenic Effects

For Aroclors having reference doses (**RfDs**) specified in IRIS (e.g., Aroclor 1254, 1016, etc.), the non-carcinogenic risk should also be evaluated. The evaluation of non-carcinogenic 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 Non-Carcinogenic Effects and Ecological Health Non-Dioxin-Like Effects

CRITERIA: Congeners with equal to or greater than four (4) chlorines comprise . . .	**NON-CARCINOGENIC 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 non-carcinogenic 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 *Exposure Assessment for Community Measurement Receptors, Section 7.2.1.1*).

[29]The cancer slope factor for 2,3,7,8-TCDD should be obtained from the most recent IRIS (US EPA, 2014). 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, 2014).

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 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 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[30]

CONGENER	FISH TOXICITY EQUIVALENCY FACTOR VALUES[31]
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[32]
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:

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

Where:

[30]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).

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

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

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

$$\mathbf{Risk = TEQ / TRV_{TCDD}} \qquad \textit{Equation D-6}$$

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:

$$\mathbf{DD_{TEQ} = \Sigma\, DD_i \times TEF_{MR}} \qquad \textit{Equation D-7}$$

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:

$$\mathbf{Risk = TEQ / TRV_{TCDD}} \qquad \textit{Equation D-8}$$

Where:

[33]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.

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)

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[34] 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[35] 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 1 µg/L in ground water with 10,000 mg/L or less total dissolved solids).

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[34]Approximately 77% of Aroclor 1254 is composed of PCB congeners with more than 4 chlorines.

[35]Approximately 99% of Aroclor 1016 is comprised of PCB congeners with 4 or less chlorines.

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VOLUME 2
SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENTS

PHASE I
Scoping Assessment

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Attachment A: Screening Level Ecological Risk Assessment Scoping Assessment Site Assessment Checklist
Attachment B: Ecological Site Exclusion Criteria Checklist and Decision Tree

Acronymns and Abbreviations

AOC	Areas of Concern
AUF	Area Use Factor
BAF	Bioaccumulation/Biomagnification Factor
bgs	below ground surface
COPEC	Constituent of Potential Ecological Concern
EPC	Exposure Point Concentration
ft	foot
GAERPC	Guidance for Assessing Ecological Risks Posed by Chemicals
HI	Hazard Index
HQ	Hazard Quotient
kg	kilogram
LOAEL	Lowest-observed adverse effect level
LULC	land use and land cover
mg	milligram
NMED	New Mexico Environment Department
NOAEL	No-observed adverse effect level
PCSEM	Preliminary Conceptual Site Exposure Model
PUF	Plant Uptake Factor
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SLERA	Screening Level Ecological Risk Assessment
SLHQ	Screening Level Hazard Quotient
SSG	Soil Screening Guidance
SWMU	Solid Waste Management Unit
T&E	Threatened and Endangered
TRV	Toxicity Reference Value
UCL	Upper Confidence Level
US EPA	United States Environmental Protection Agency

1.0 INTRODUCTION

The purpose of an ecological risk assessment is to evaluate the potential adverse effects that chemical contamination has on the plants and animals that make up ecosystems. The risk assessment process provides a way to develop, organize and present scientific information so that it is relevant to environmental decisions.

The New Mexico Environment Department (NMED) has developed a tiered procedure for the evaluation of ecological risk. Volume II of this *Risk Assessment Guidance for Investigations and Remediation* (SSG) outlines the steps for the Phase I Assessment, to include a qualitative scoping assessment and a quantitative screening assessment. If more detailed assessments are required or the Phase II Assessment is needed, additional guidance may be found in the *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment* (GAERPC) (NMED, 2014). Briefly, the tiers of the procedure are organized as follows:

PHASE I – SCOPING AND SCREENING ASSESSMENTS

- Scoping Assessment
- Screening Assessment (Tier 1 and 2)

PHASE II - SITE-SPECIFIC ASSESSMENTS

- Site-Specific Ecological Risk Assessment (Tier 3)

As discussed above and illustrated in Figure 1, the Scoping Assessment is the first phase of the Screening-Level Ecological Risk Assessment process as defined by the NMED GAERPC. This document provides specific procedures to assist the facility in conducting the first phase (Scoping and Screening Assessments), Screening-Level Ecological Risk Assessment process outlined in the GAERPC. The purpose of the Scoping Assessment is to gather information, which will be used to determine if there is "any reason to believe that ecological receptors and/or complete exposure pathways exist at or in the locality of the site" (NMED, 2014). The scoping assessment step also serves as the initial information-gathering phase for sites clearly in need of a more detailed assessment of potential ecological risk. This document outlines the methodology for conducting a Scoping Assessment, and includes a Site Assessment Checklist (Attachment A), which serves as tool for gathering information about the facility property and surrounding areas. Although the GAERPC provides a copy of the US Environmental Protection Agency (US EPA) Checklist for Ecological Assessment/Sampling (US EPA, 1997), the attached Site Assessment Checklist provides an expanded, user-friendly template, which both guides the user as to what information to collect and furnishes an organized structure in which to enter the information.

After the Site Assessment Checklist has been completed, the assessor must use the collected information to generate a Scoping Assessment Report and Preliminary Conceptual Site Exposure Model (PCSEM). Guidance for performing these tasks is provided in this document, and in the GAERPC. The Scoping Assessment Report and PCSEM are subsequently used to address the first in a series of Technical Decision Points of the tiered GAERPC process. Technical Decision Points are questions which must be answered by the assessor after the completion of certain

phases in the process. The resulting answer to the question determines the next step to be undertaken by the facility. The first Technical Decision Point, as illustrated in Figure 1, is to decide: *Is Ecological Risk Suspected?*

If the answer to the first Technical Decision Point is "no" (that is, ecological risk is not suspected), the assessor may use the Exclusion Criteria Checklist and Decision Tree (Attachment B) to help confirm or deny that possibility. However, it is unlikely that any site containing potential ecological habitat or receptors will meet the Site Exclusion Criteria.

If ecological risk is suspected, the facility will usually be directed to proceed to the Tier 1 Screening Level Ecological Risk Assessment (SLERA) and refined Tier 2 SLERA. A SLERA is a simplified risk assessment that can be conducted with limited site-specific data by defining assumptions for parameters that lack site-specific data (US EPA, 1997). Values used for screening are consistently biased in the direction of overestimating risk to ensure that sites that might pose an ecological risk are properly identified. The completed Site Assessment Checklist is a valuable source of information needed for the completion of the SLERA. Additional information on performing a SLERA can be found in the GAERPC (NMED, 2014) and in a number of EPA guidance documents (e.g., US EPA, 1997; US EPA, 1998).

2.0 SCOPING ASSESSMENT

The Scoping Assessment serves as the initial information gathering and evaluation for the Phase I process. A Scoping Assessment consists of the following steps:

- Compile and Assess Basic Site Information (using Site Assessment Checklist)
- Conduct Site Visit
- Identify Preliminary Contaminants of Potential Ecological Concern
- Develop a Preliminary Conceptual Site Exposure Model
- Prepare a Scoping Assessment Report

The following subsections provide guidance for completing each step of the Scoping Assessment. For additional guidance, readers should refer to the GAERPC (NMED, 2014).

2.1 Compile and Assess Basic Site Information

The first step of the Scoping Assessment process is to compile and assess basic site information. Since the purpose of the Scoping Assessment is to determine if ecological habitats, receptors, and complete exposure pathways are likely to exist at the site, those items are the focus of the information gathering. The Site Assessment Checklist (Attachment A) should be used to complete this step. The questions in the Site Assessment Checklist should be addressed as completely as possible with the information available before conducting a site visit.

In many cases, a large portion of the Site Assessment Checklist can be completed using reference materials and general knowledge of the site. A thorough file search should be conducted to

compile all potential reference materials. Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) and Facility Investigation (RFI) reports, inspection reports, RCRA Part B Permit Applications, and facility maps can all be good sources of the information needed for the Site Assessment Checklist.

Habitats and receptors which may be present at the site can be identified by contacting local and regional natural resource agencies. Habitat types may be determined by reviewing land use and land cover maps (LULC), which are available via the Internet at http://www.nationalatlas.gov/scripts. Additional sources of general information for the identification of ecological receptors and habitats are listed in the introduction section of the Site Assessment Checklist (Attachment A).

After all available information has been compiled and entered into the Site Assessment Checklist, the assessor should review the checklist and identify data gaps. Plans should then be made to obtain the missing information by performing additional research and/or by observation and investigation during the site visit.

2.2 Site Visit

When performing a Scoping Assessment, at least one site visit should be conducted to directly assess ecological features and conditions. As discussed in the previous section, completion of the Site Assessment Checklist should have begun during the compilation of basic site information. The site visit allows for verification of the information obtained from the review of references and other information sources. The current land and surface water usage and characteristics at the site can be observed, as well as direct and indirect evidence of receptors. In addition to the site, areas adjacent to the site and all areas where ecological receptors are likely to contact site-related chemicals (i.e., all areas which may have been impacted by the release or migration of chemicals from the site) should be observed or visited and addressed in the Site Assessment Checklist. The focus of the habitat and receptor observations should be on a community level. That is, dominant plant and animal species and habitats (e.g., wetlands, wooded areas) should be identified during the site visit. Photographs should be taken during the site visit and attached to the Scoping Assessment Report. Photographs are particularly useful for documenting the nature, quality, and distribution of vegetation, other ecological features, potential exposure pathways, and any evidence of contamination or impact. While the focus of the survey is on the community level, the U.S. Fish and Wildlife Service and the New Mexico Natural Heritage Program should be contacted prior to the site visit. The intent is to determine if state listed and/or federal listed Threatened & Endangered (T&E) species or sensitive habitats may be present at the site, or if any other fish or wildlife species could occur in the area (as indicated in the Site Assessment Checklist, Section IIID). A trained biologist or ecologist should conduct the biota surveys to appropriately characterize major habitats and to determine whether T&E species are present or may potentially use the site. The site assessment should also include a general survey for T&E species and any sensitive habitats (e.g. wetlands, perennial waters, breeding areas), due to the fact that federal and state databases might not be complete.

Site visits should be conducted at times of the year when ecological features are most apparent (i.e., spring, summer, early fall). Visits during winter might not provide as much evidence of the presence or absence of receptors and potential exposure pathways.

In addition to observations of ecological features, the assessor should note any evidence of chemical releases (including visual and olfactory clues), drainage patterns, areas with apparent erosion, signs of groundwater discharge at the surface (such as seeps or springs), and any natural or anthropogenic site disturbances.

2.3 Identify Contaminants of Potential Ecological Concern

Contaminants of Potential Ecological Concern (COPECs) are chemicals which may pose a threat to individual species or biological communities. For the purposes of the Scoping Assessment, all chemicals known or suspected of being released at the site are considered COPECs. The identification of COPECs is usually accomplished by the review of historical information in which previous site activities and releases are identified, or by sampling data which confirm the presence of contaminants in environmental media at the site. If any non-chemical stressors such as mechanical disturbances or extreme temperature conditions are known to be present at the site, they too are to be considered in the assessment.
After the COPECs have been identified, they should be summarized and organized (such as in table or chart form) for presentation in the Scoping Assessment Report.

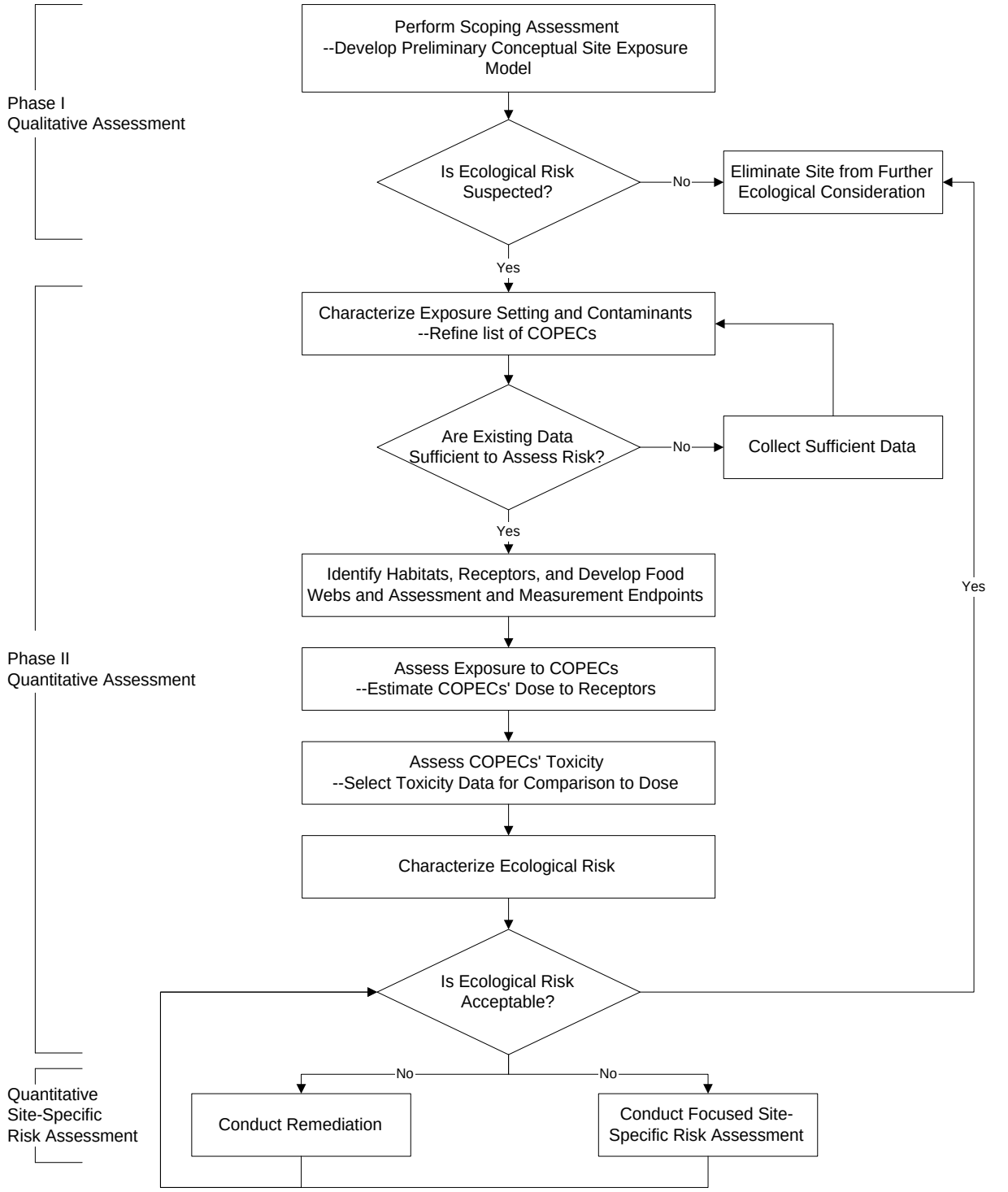
2.4 Developing the Preliminary Conceptual Site Exposure Model

A PCSEM provides a summary of potentially complete exposure pathways, along with potentially exposed receptor types. The PCSEM, in conjunction with the scoping report, is used to determine whether further ecological assessment (i.e., Screening-Level Assessment, Site-Specific Assessment) and/or interim measures are required.

A complete exposure pathway is defined as a pathway having all of the following attributes (US EPA, 1998; NMED, 2014):

- A source and mechanism for hazardous waste/constituent release to the environment
- An environmental transport medium or mechanism by which a receptor can come into contact with the hazardous waste/constituent
- A point of receptor contact with the contaminated media or via the food web, and
- An exposure route to the receptor.

If any of the above components are missing from the exposure pathway, it is not a complete pathway for the site. A discussion regarding all possible exposure pathways and the rationale/justification for eliminating any pathways should be included in the PCSEM narrative and in the Scoping Assessment Report.



Adapted from GAERPC (NMED 2000).

Figure 1. NMED Ecological Risk Assessment Process

The PCSEM is presented as both a narrative discussion and a diagram illustrating potential contaminant migration and exposure pathways to ecological receptors. A sample PCSEM diagram is presented in Figure 2. On the PCSEM diagram, the components of a complete exposure pathway are grouped into three main categories: sources, release mechanisms, and potential receptors. As a contaminant migrates and/or is transformed in the environment, sources and release mechanisms can be defined as primary, secondary, and tertiary.

For example, Figure 2 depicts releases from a landfill that migrate into soils, and reach nearby surface water and sediment via storm water runoff. In this situation, the release from the landfill is considered the primary release, with infiltration as the primary release mechanism. Soil becomes the secondary source, and storm water runoff is the secondary release mechanism to surface water and sediments, the tertiary source.

Subsequent ecological exposures to terrestrial and aquatic receptors will result from this release. The primary exposure routes to ecological receptors are direct contact, ingestion, and possibly inhalation. For example, plant roots will be in direct contact with contaminated sediments, and burrowing mammals will be exposed via dermal contact with soil and incidental ingestion of contaminated soil. In addition, exposures for birds and mammals will occur as they ingest prey items through the food web.

Although completing the Site Assessment Checklist will not provide the user with a readymade PCSEM, a majority of the components of the PCSEM can be found in the information provided by the Site Assessment Checklist. The information gathered for the completion of Section II of the Site Assessment Checklist, can be used to identify sources of releases. The results of Section III, Habitat Evaluation, can be used to both identify secondary and tertiary sources and to identify the types of receptors which may be exposed. The information gathered for completion of Section IV, Exposure Pathway Evaluation, will assist users in tracing the migration pathways of releases in the environment, thus helping to identify release mechanisms and sources.

Once all of the components of the conceptual model have been identified, complete exposure pathways and receptors that have the potential for exposure to site releases can be identified.

For further guidance on constructing a PCSEM, consult the GAERPC (NMED, 2014), and US EPA guidance on corrective action, to include the site conceptual exposure model builder (http://www.epa.gov/osw/hazard/correctiveaction/resources/guidance/index.htm).

2.5 Assembling the Scoping Assessment Report

After completion of the previously described activities of the scoping assessment, the Scoping Assessment Report should be assembled to summarize the site information and present an evaluation of receptors and pathways at the site. The Scoping Assessment Report should be designed to support the decision made regarding the first Technical Decision Point (Is Ecological Risk Suspected?). The Scoping Assessment Report should, at a minimum, contain the following information:

- Existing Data Summary
- Site Visit Summary (including a completed Site Assessment Checklist)

- Evaluation of Receptors and Pathways
- Recommendations
- Attachments (e.g. photographs, field notes, telephone conversation logs with natural resource agencies)
- References/Data Sources

After completion, the Scoping Assessment Report and PCSEM should be submitted to NMED for review and approval. These documents will serve as a basis for decisions regarding future actions at the site.

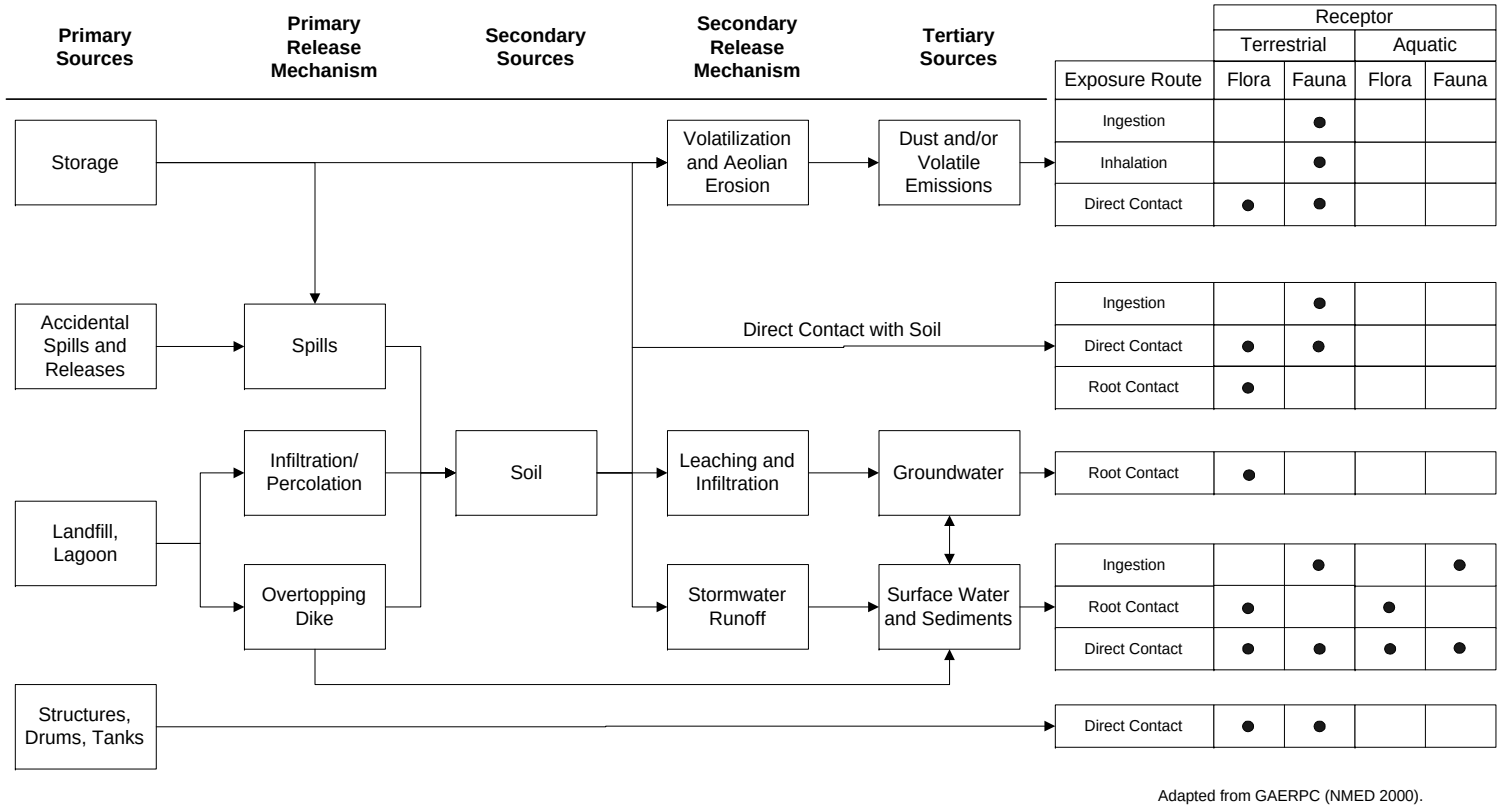


Figure 2. Example Preliminary Conceptual Site Exposure Model Diagram for a Hypothetical Site

2.6 Site Exclusion Criteria

If the assessor believes that the answer to the first Technical Decision Point (Is Ecological Risk Suspected?) is "no" based on the results of the PCSEM and Scoping Assessment Report, it should be determined whether the facility meets the NMED Site Exclusion Criteria.

Exclusion criteria are defined as those conditions at an affected property which eliminate the need for a SLERA. The three criteria are as follows:

- Affected property does not include viable ecological habitat.
- Affected property is not utilized by potential receptors.
- Complete or potentially complete exposure pathways do not exist due to affected property setting or conditions of affected property media.

The Exclusion Criteria Checklist and associated Decision Tree (Attachment B) can be used as a tool to help the user determine if an affected site meets the exclusion criteria. The checklist assists in making a conservative, qualitative determination of whether viable habitats, ecological receptors, and/or complete exposure pathways exist at or in the locality of the site where a release of hazardous waste/constituents has occurred. Thus, meeting the exclusion criteria means that the facility can answer "no" to the first Technical Decision Point.

If the affected property meets the Site Exclusion Criteria, based on the results of the checklist and decision tree, the facility must still submit a Scoping Assessment Report to NMED which documents the site conditions and justification for how the criteria have been met. Upon review and approval of the exclusion by the appropriate NMED Bureau, the facility will not be required to conduct any further evaluation of ecological risk. However, the exclusion is not permanent; a future change in circumstances may result in the affected property no longer meeting the exclusion criteria.

2.7 Technical Decision Point: Is Ecological Risk Suspected?

As discussed in the beginning of this document, the Scoping Assessment is the first phase of the GAERPC ecological risk assessment process (Figure 1). Following the submission of the Scoping Assessment Report and PCSEM, NMED will decide upon one of the following three recommendations for the site:

- No further ecological investigation at the site, or
- Continue the risk assessment process, and/or
- Undertake a removal or remedial action.

If the information presented in the Scoping Assessment Report supports the answer of "no" to the first Technical Decision Point, and the site meets the exclusion criteria, the site will likely be excused from further consideration of ecological risk. However, this is only true if it can be documented that a complete exposure pathway does not exist and will not exist in the future at the site based on current conditions. For those sites where valid pathways for potential exposure exist or are likely to exist in the future, further ecological risk assessment (usually in the form of

a SLERA) will be required. However, if the Scoping Assessment indicates that a detailed assessment is warranted, the facility would not be required to conduct a SLERA. Instead the facility would move directly to Phase II and the Site-Specific Ecological Risk Assessment (Tier 3).

3.0 TIER 1 SCREENING LEVELS ECOLOGICAL RISK ASSESSMENT (SLERA)

If the PSCEM indicates complete exposure pathways, a SLERA is most likely the next step. The data collected during the scoping assessment is used to define facility-wide conditions and define the steps needed for the SLERA and includes the below items. The SLERA should contain a detailed discussion of each of these items.

- Characterization of the environmental setting, including current and future land uses. Ecological assessments must include the evaluation of present day conditions and land uses but also evaluate future land uses.
- Identification of known or likely chemical stressors (chemicals of potential ecological concern, COPECs). The characterization data from the site (e.g., facility investigation) is evaluated to determine what constituents are present in which media. Selection of COPEC should follow the same methodology as outlined in Volume I.
- Identification of the fate and transport pathways that are complete. This includes an understanding of how COPECs may be mobilized from one media to another.
- Identification of the assessment endpoints that should be used to assess impact of the receptors; what is the environmental value to be protected.
- Identification of the complete exposure pathways and exposure routes (as identified in the example in Figure 2). What are the impacted media (soil, surface water, sediment, groundwater, and/or plants) and how might the representative receptors be exposed (direct ingestion, inhalation, and/or direct contact)?
- Species likely to be impacted and selection of representative receptors. From the list of species likely to be present on-site, what species are to be selected to represent specific trophic levels?

3.1 Selection of Representative Species

Sites may include a wide range of terrestrial, semi-aquatic, and aquatic wildlife. A generalized food web is shown in Figure 3. Wildlife receptors for the SLERA should be selected to represent the trophic levels and habitats present or potentially present at the site and include any Federal threatened and endangered species and State sensitive species.

As there are typically numerous species of wildlife and plants present at a given facility or site and in the surrounding areas, only a few key receptors need to be selected for quantitative evaluation in the SLERA, which are representative of the ecological community and varying

trophic levels in the food web. Possible receptors that may be evaluated in the SLERAs at each site include the following:

- Plant community,
- Deer mouse,
- Horned lark,
- Kit fox (evaluated at sites greater than 267 acres),
- Pronghorn (evaluated at sites greater than 342 acres), and
- Red-tailed hawk (evaluated at sites greater than 177 acres).

The above key receptors selected as the representative species represent the primary producers as well as the three levels of consumer (primary, secondary, and tertiary).

3.1.1 Plants

The plant community will be evaluated quantitatively in the SLERAs at all sites. Specific species of plants will not be evaluated separately; rather the plant community will be evaluated as a whole. The plant community provides a necessary food source directly or indirectly through the food web for wildlife receptors.

3.1.2 Deer Mouse

The deer mouse (Peromyscus maniculatus) is a common rodent throughout much of North America and it can thrive in a variety of habitats. The deer mouse was selected as a representative receptor because it is prevalent in the vicinity of most sites in New Mexico, and it represents one of the several species of omnivorous rodents that may be present at sites. Small rodents are also a major food source for larger omnivorous and carnivorous species. The deer mouse receptor will be evaluated at all sites, regardless of size. The deer mouse has a relatively small home range and could therefore be substantially exposed to COPECs at sites if their home range is located within a solid waste management unit (SWMU) or other corrective action site.

Based on a review of literature (OEHHA, 1999) and from the Natural Diversity Information Source (CDW, 2011), a dietary composition consisting of 26% invertebrates and 74% plant matter will be assumed for the deer mouse.

3.1.3 Horned Lark

The horned lark (*Eremophila alpestris*) is a common widespread terrestrial bird. It spends much of its time on the ground and its diet consists mainly of insects and seeds. The horned lark receptor was chosen because it is prevalent in New Mexico and represents one of the many small terrestrial bird species that could be present. Since the horned lark spends most of its time on the ground, it also provides a conservative measure of effect since it has a higher rate of incidental ingestion of soil than other song birds. The horned lark is also a major food source for

omnivorous intermediate species, and top avian carnivores. The horned lark will be evaluated based on an omnivorous diet of invertebrates and plant matter. The horned lark receptor will be evaluated at all sites, regardless of size. The horned lark has a relatively small home range and could therefore be substantially exposed to COPECs at sites if their home range is located within a SWMU or other corrective action unit.

It will be assumed that the horned lark's diet consists of 75% plant matter, and 25% animal matter based on a study conducted by Doctor, *et al*, 2000.

3.1.4 Kit Fox

The kit fox (*Vulpes macrotis*) is native to the western United States and Mexico. Its diet consists of mostly small mammals. Although the kit fox's diet may also consist of plant matter during certain times of the year, the kit fox will be evaluated as a carnivore, with a diet consisting of 100% prey items. It was selected as a key receptor because it is sensitive species and is common in New Mexico, and the surrounding area at most sites in New Mexico provides suitable habitat for the kit fox. The kit fox also is representative of a mammalian carnivore within the food web.

The kit fox will only be evaluated at sites that are larger than 276 acres. A kit fox has a large home range size (2767 acres) (Zoellick & Smith, 1992) and it is assumed that risks are negligible from exposure to COPECs at sites that are less than 10% of the receptors home range. Unless the area use factor (AUF) is at least 10%, food items potentially contaminated with COPECs and incidental soil ingestion at the site would not contribute significantly to the receptor's diet and exposure to COPECs. The kit fox diet will be based on composition of 100% prey.

3.1.5 Red-Tailed Hawk

The red-tailed hawk (*Buteo jamaicensis*) was selected as a top carnivore avian key receptor. The red-tailed hawk is widespread throughout New Mexico and is one of the most common birds of prey. It hunts primarily rodents, rabbits, birds, and reptiles. The red-tailed hawk was chosen as a key receptor since it is a common species through New Mexico. The red-tailed hawk will only be evaluated at sites that are larger than 177 acres. The red-tailed hawk has a large home range size (1770 acres) (US EPA, 1993b), and risks to the red-tailed hawk from exposure to COPECs at sites smaller than 177 acres (10% of the home range) would be negligible. The red-tailed hawk diet will be based on composition of 100% prey.

3.1.6 Pronghorn Antelope

The pronghorn (*Antilocapra Americana*) is a popular big game species that occurs in western Canada, United States, and northern Mexico. Its diet consists mainly of sagebrush and other shrubs, grasses, and forbs. The pronghorn was selected as a key receptor representative of large herbivorous species of wildlife. The pronghorn will only be evaluated at sites that are larger than 342 acres. The pronghorn has a large home range size (3422 acres) (Reynolds, 1984), and risks to the pronghorn from exposure to COPECs at sites smaller than 342 acres (10% of the home range) would be negligible. It is assumed that 100% of the diet is from grazing.

3.2 Exposure Pathways

The scoping survey will provide a summary of potentially complete exposure pathways, along with potentially exposed receptor types. A complete exposure pathway is defined as a pathway having all of the following attributes:

- A source and mechanism for hazardous waste/constituent release to the environment,
- An environmental transport medium or mechanism by which a receptor can come into contact with the hazardous waste/constituent,
- A point of receptor contact with the contaminated media or via the food web, and
- An exposure route to the receptor.

If any of the above components are missing from the exposure pathway, it is not a complete pathway for the site. A discussion regarding all possible exposure pathways and the rationale/justification for eliminating any pathways will be included in the risk assessment.

Affected media that ecological receptors may be exposed to at sites are soil, biota, and surface water or groundwater (through springs). Surface water, sediment, and groundwater should be evaluated based on site-specific conditions.

Wildlife receptors could be exposed to COPECs that have been assimilated into biota. Ingestion of contaminated plant and animal matter, as a necessary component of the receptor's diet, will be evaluated quantitatively in the SLERAs. However, for the Tier-1 SLERA, it will conservatively be assumed that 100% of the wildlife receptors' dietary intake consists of site soil.

For soil, two soil intervals should be evaluated:

- For all non-burrowing receptors, the soil interval to be considered is between zero (0) and five (5) feet below ground surface (ft bgs).
- For all burrowing receptors and plants, the soil interval to be evaluated is 0 – 10 ft bgs.

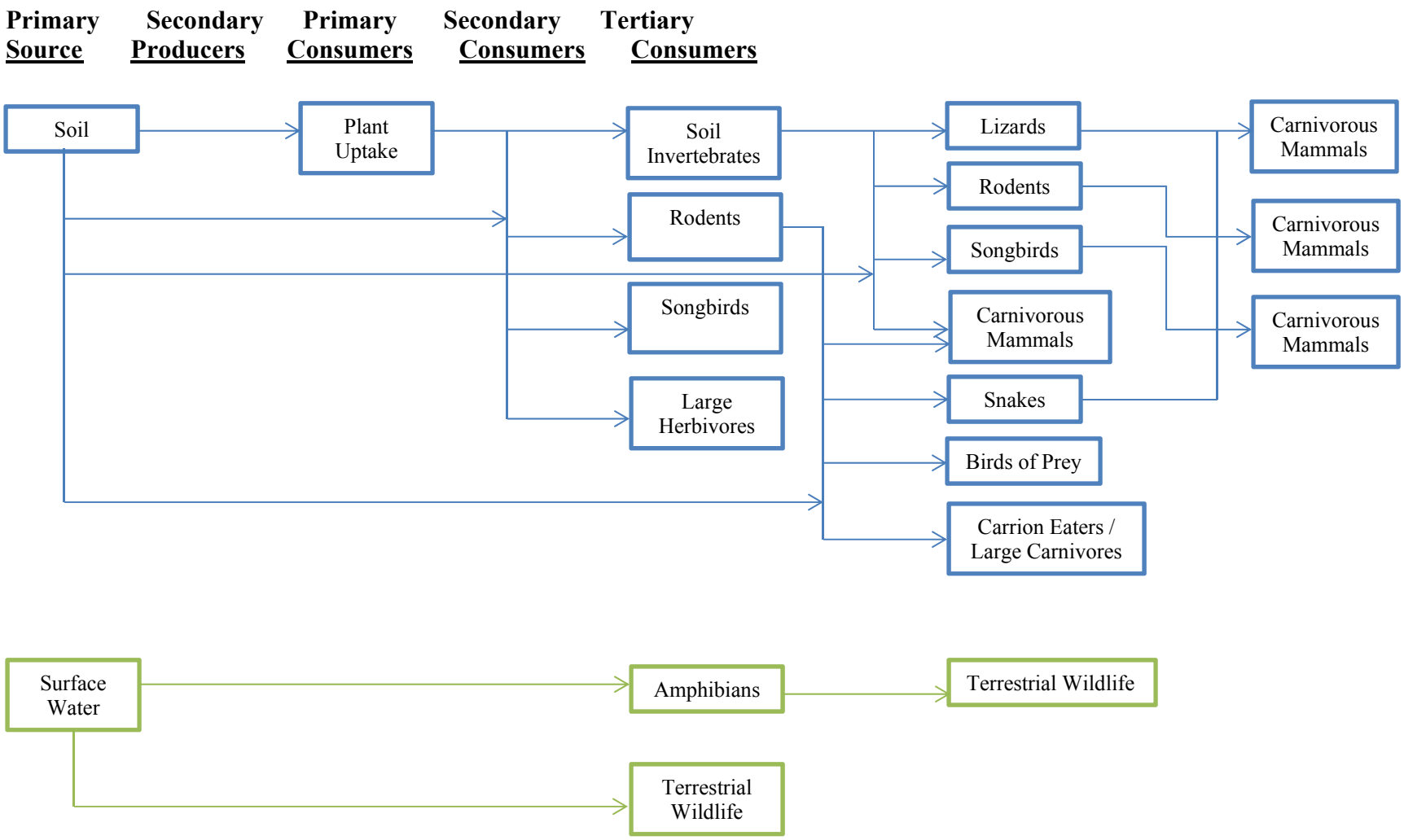


Figure 3. Generic Food Web.

3.3 SLERA Exposure Estimation

For the initial SLERA, conservative assumptions should be applied as follows:

- Maximum detected concentrations (0-10 ft bgs for all receptors) will be utilized in calculating exposure doses.
- 100% of the diet is assumed to contain the maximum concentration of each COPEC detected in the site media.
- Minimum reported body weights should be applied.
- Maximum dietary intake rates should be used.
- It will be assumed that 100% of the diet consists of direct ingestion of contaminated soil.
- It is assumed that the bioavailability is 100% at each site.
- Foraging ranges are initial set equal to the size of the site being evaluated. This means that the AUF in the SLERA is set to a value of one.

The equation and exposure assumptions for calculating the Tier 1 exposure doses for the deer mouse are presented in Equation 1.

Equation 1. Calculation of Tier 1 Exposure Dose for COPECs in Soil; Deer Mouse

$$Exposure\ Dose = \frac{(C_s \times (IR * ww{:}\,dw)\ \times AUF)}{BW}$$

Parameter	Definition (units)	Value	Reference
Exposure Dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	calculated	--
C_s	Chemical concentration in soil (mg/kg)	Site-specific	Maximum detected concentration (0-10 ft bgs)
IR	Ingestion rate (kg food [ww]/day)	0.007	Maximum reported total dietary intake (US EPA, 1993b)
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
AUF	Area use factor (the ratio of the site exposure area to the receptor foraging range) (unitless)	1	Maximum possible value
BW	Body weight (kg)	0.014	Minimum reported adult body weight (CDW, 2011)

The equation and exposure assumptions for calculating the Tier 1 exposure dose for the horned lark are presented in Equation 2.

Equation 2. Calculation of Tier 1 Exposure Dose for COPECs in Soil; Horned Lark

$$Exposure\ Dose = \frac{(C_s \times (IR * ww{:}dw) \times AUF)}{BW}$$

Parameter	Definition (units)	Value	Reference
Exposure Dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_s	Chemical concentration in soil (mg/kg)	Site-specific	Maximum detected concentration (0-10 ft bgs)
IR	Ingestion rate (kg food [ww]/day)	0.024	Maximum reported total dietary intake; American robin (US EPA, 1993b)
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
AUF	Area use factor (the ratio of the site exposure area to the receptor foraging range) (unitless)	1	Maximum possible value
BW	Body weight (kg)	0.025	Minimum reported adult body weight (Trost, 1972)

The equation and exposure assumptions for calculating the Tier 1 exposure doses for the kit fox are presented in Equation 3.

Equation 3. Calculation of Tier 1 Exposure Dose for COPECs in Soil; Kit Fox

$$Exposure\ Dose = \frac{(C_s \times (IR * ww{:}dw) \times AUF)}{BW}$$

Parameter	Definition (units)	Value	Reference
Exposure Dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	calculated	--
C_s	Chemical concentration in soil (mg/kg)	Site-specific	Maximum detected concentration (0-10 ft bgs)
IR	Ingestion rate (kg food [ww]/day)	0.18	Maximum reported total dietary intake (OEHHA, 2003)
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
AUF	Area use factor (the ratio of the site exposure area to the receptor foraging range) (unitless)	1	Maximum possible value
BW	Body weight (kg)	1.6	Minimum reported adult body weight (OEHHA, 2003)

The equation and exposure assumptions for calculating the Tier 1 exposure doses for the red-tailed hawk are presented in Equation 4.

Equation 4 Calculation of Tier 1 Exposure Dose for COPECs in Soil; Red-tailed Hawk			
$$Exposure\ Dose = \frac{(C_s \times (IR * ww{:}dw) \times AUF)}{BW}$$			
Parameter	**Definition (units)**	**Value**	**Reference**
Exposure Dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_s	Chemical concentration in soil (mg/kg)	Site-specific	Maximum detected concentration (0-10 ft bgs)
IR	Ingestion rate (kg food [ww]/day)	0.12	Maximum reported total dietary intake (US EPA, 1993b)
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
AUF	Area use factor (the ratio of the site exposure area to the receptor foraging range) (unitless)	1	Maximum possible value
BW	Body weight (kg)	0.96	Minimum reported adult body weight (US EPA, 1993b)

The equation and exposure assumptions for calculating the Tier 1 exposure doses for the pronghorn are presented in Equation 5.

Equation 5. Calculation of Tier 1 Exposure Dose for COPECs in Soil; Pronghorn			
$$Exposure\ Dose = \frac{(C_s \times (IR * ww{:}dw) \times AUF)}{BW}$$			
Parameter	**Definition (units)**	**Value**	**Reference**
Exposure Dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	calculated	--
C_s	Chemical concentration in soil (mg/kg)	Site-specific	Maximum detected concentration (0-10 ft bgs)
IR	Ingestion rate (kg wet matter/day) Based on equation: $IR=a(BW)^b$ where: a=2.606, b=0.628	0.74	Dry matter intake rate for herbivores (based on Nagy, 2001)
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
AUF	Area use factor (the ratio of the site exposure area to the receptor foraging range) (unitless)	1	Maximum possible value
BW	Body weight (kg)	47	Minimum reported adult body weight (O'Gara, 1978)

Exposure doses will not be calculated for plants. For the Tier 1 exposure assessment, it will be assumed that the exposure concentrations for plants are equal to the maximum detected concentrations of COPECs in soil (0-10 ft bgs).

3.4 Effects Assessment

The effects assessment evaluated the potential toxic effects on the receptors being exposed to the COPECs. The effects assessment includes selection of appropriate toxicity reference values (TRVs) for the characterization and evaluation of risk. TRVs are receptor and chemical specific exposure rates at which no adverse effects have been observed, or at which low adverse effects are observed. TRVs that are based on studies with no adverse effects are called no observed adverse effects levels (NOAELs). TRVs that are based on studies with low adverse effects are termed lowest observed adverse effects levels (LOAELs).

For the initial SLERA, the preference for TRVs is based on chronic or long term exposure, when available. The TRVs should be selected from peer-reviewed toxicity studies and from primary literature. Initial risk characterization should be conducted using the lowest appropriate chronic NOAEL for non-lethal or reproductive effects. If a TRV is not available and/or no surrogate data could be identified, the exclusion of potential toxicity associated with the COPEC will be qualitatively addressed in the uncertainty analysis of the risk assessment. Other factors that may be included in this discussion is frequency of detection, depth of detections, and special analysis of the detections.

3.5 Risk Characterization

Assessment endpoints are critical values to be protected (US EPA, 1997c). The assessment endpoint will be to ensure the survival and reproduction of all ecological receptors to maintain populations. This will be accomplished by determining whether COPECs at each site are present at levels that would adversely affect the population size of ecological receptors by limiting their abilities to reproduce.

For plants, the Tier 1 screening level hazard quotients for plants will be calculated by comparing exposure doses (i.e., maximum detected concentrations of COPECs; 0-10 ft bgs) to an effect concentration. The equation for screening level hazad quotient (SLHQ) for plants is shown in Equation 6.

Equation 6. Calculation of Screening-Level Hazard Quotients for Plant Receptors

$$SLHQ = \frac{C_s}{Effect\ Concentration}$$

Parameter	Definition (units)
SLHQ	Screening level hazard quotient (unitless)
C_s	Chemical concentration in soil (mg COPEC / kg soil dry weight)

Effect Concentration	Concentration at which adverse effects are not expected (mg/kg)

Tier 1 SLHQs for wildlife receptors will be calculated by comparing estimated exposure doses derived using Equations 1 through 5 for each of the key receptors determined to have complete habitat and exposure pathways at the site to NOAEL-based TRVs. The derivation of SLHQ for the key receptors (except plants) is shown in Equation 7.

Equation 7 Calculation of Screening-Level Hazard Quotients for Wildlife Receptors	
$$SLHQ = \frac{Dose}{TRV}$$	
Parameter	**Definition (Units)**
SLHQ	Screening-level hazard quotient (unitless)
Dose	Estimated receptor-specific contaminant intake, from Equations 1 through 5 (mg/kg of body weight/day)
TRV	NOAEL-based TRV (mg/kg/day)
C_s	Chemical concentration in soil (mg COPEC / kg soil dry weight)

HQs are calculated for each receptor and each COPEC. For each receptor, additive risk must be evaluated. For the initial screening assessment, it is assumed that all COPECs have equal potential risk to the receptor. The overall hazard index (HI) is then calculated for each receptor using Equation 3:

$$HI = HQ_x + HQ_Y + ... + HQ_z \qquad \text{Equation 8}$$

Where:

HI = Hazard Index (unitless)
HQ_X = Hazard quotient for each COPEC (unitless)

NMED applies a target risk level for ecological risk assessments of 1.0. If the HI for any receptor is above this target risk level, then there is a potential for adverse effects on ecological receptors and additional evaluation following the Tier 2 SLERA process is required.

As with all risk assessments, the SLERA should include a discussion of the uncertainties. More detailed information may be found in the *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment (NMED, 2014).*

4.0 TIER 2 SLERA

The Tier 2 exposure assessment will consist of calculating refined estimates of exposure doses which will utilize exposure assumptions that are more realistic. The following assumptions will apply to Tier 2 exposure doses:

- Exposure Point Concentration (EPC) – 95 % upper confidence level of the mean (UCLs) will be utilized as the EPC (if sufficient data are available – refer to Volume I for determination of EPCs and UCLs).
- AUF – Site-specific value between 0 and 1, based on the ratio of the exposure area (size of SWMU or corrective action site) to the receptor's average home range size, as shown in Equation 9; if a receptor's home range size is less than the exposure area, a value of 1 will be assumed.

$$AUF = \frac{Exposure\ Area\ of\ Site\ (acres)}{Average\ Home\ Range\ (acres)} \qquad \textbf{Equation 9}$$

- Bioavailability – It will be assumed that the bioavailability is 100% at each site.
- Body weight – The average reported adult body weight will be applied.
- Ingestion rate – The average reported ingestion rate will be applied.
- Dietary composition – Receptor-specific percentages of plant, animal, and soil matter will be considered. Concentrations of COPECs in dietary elements (plant and animal matter) will be predicted by the use of bio-uptake and bioaccumulation modeling.
- Wet-weight to dry-weight conversion factor – Because body weight is reported as wet-weight (kg), and soil concentrations are reported as dry-weight (mg/kg), a wet-weight to dry-weight conversion factor will also be applied when calculating exposure doses.

The Tier 2 exposure doses for wildlife receptors will include one, two or all three of the following elements, depending on the receptor being evaluated: 1) ingestion of plant matter; 2) ingestion of animal (or invertebrate) matter; and 3) incidental ingestion of soil. Bio-uptake and bioaccumulation modeling will be utilized to predict the concentrations of COPECs in plants and animal/invertebrate matter that could be ingested by wildlife receptors. Evaluation of surface and/or groundwater should be discussed with NMED.

Plant uptake factors (PUFs) will be used to predict the concentrations of COPECs in plants. The PUFs for inorganic constituents are summarized in Table 1. For organic COPECs, the PUFs are based on the octanol-water partition coefficient (K_{ow}), which will be obtained from US EPA databases or primary literature.

If a PUF is not available, then a value of one (1) will be applied which assumes 100% assimilation. The equation and variables that will be used to predict COPEC concentrations in plants are shown in Equation 10.

Equation 10. Calculation of COPEC Concentrations in Plants		
$$C_{plant} = C_{soil} \times PUF$$		
Parameter	**Definition (Units)**	**Value**
C_{plant}	COPEC concentration in plant (mg/kg dry weight)	Calculated
C_{soil}	Concentration of COPEC in soil (EPC) (mg/kg dry weight)	Site-specific
PUF	Plant-uptake factor (unitless)	For inorganics (see Table 1) For organic constituents (Travis and Arms, 1988): PUF = 1.588 – 0.578 log K_{ow} K_{ow}- obtain from EPA, 2011b or most current

Table 1. Plant Uptake Factors for Inorganics

Analyte	Plant Uptake Factor (PUF)	Analyte	Plant Uptake Factor (PUF)
Aluminum	4.0E-03	Magnesium	1.0E+00
Antimony	2.0E-01	Manganese	2.5E-01
Arsenic	4.0E-02	Mercury	9.0E-01
Barium	1.5E-01	Molybdenum	2.5E-01
Beryllium	1.0E-02	Nickel	6.0E-02
Boron	4.0E+00	Potassium	1.0E+00
Cadmium	5.5E-01	Selenium	2.5E-02
Calcium	3.5E+00	Silver	4.0E-01
Chromium	7.5E-03	Sodium	7.5E-02
Cobalt	2.0E-02	Thallium	4.0E-03
Copper	4.0E-01	Tin	3.0E-02
Iron	4.0E-03	Vanadium	5.5E-03
Lead	4.5E-02	Zinc	1.5E+00
From Baes, *et.al,* 1994			

Concentrations of COPECs in animal matter (invertebrates and prey species) will be predicted by applying bioaccumulation or biomagnification factors (BAFs). The BAFs will be selected from primary literature sources. If BAF data are not available, a default value of 1 will be used, which will conservatively assume 100% assimilation. Methodology for determining BAFs for soil to plants, soil to earthworms, and soil to small mammals may be found in US EPA (2003(b) and 2005). The equation and variables for predicting concentrations in animal matter are shown in Equation 11.

Equation 11. Calculation of COPEC Concentrations in Prey		
$$C_{prey} = C_{soil} \times BAF$$		
Parameter	**Definition (Units)**	**Value**
C_{prey}	COPEC concentration in prey (mg/kg dry weight)	Calculated
C_{soil}	Concentration of COPEC in soil (EPC) (mg/kg dry weight)	Site-specific
BAF	Bioaccumulation/Biomagnification factor	Chemical-specific (see US EPA 2003(b) and 2005)

The equation and exposure assumptions that will be used to calculate the Tier 2 exposure doses for the deer mouse are shown in Equation 12.

Equation 12. Calculation of Tier 2 Exposure Dose for COPECs in Soil; Deer Mouse			
$$Exposure\ Dose = \frac{\left[\left(C_{plant} \times \frac{IR_{plant}}{ww{:}\,dw}\right) + \left(C_{invert} \times \frac{IR_{invert}}{1/ww{:}\,dw}\right) + (C_{soil} \times IR_{soil} \times ST) \times AUF\right]}{BW}$$			
Parameter	**Definition (Units)**	**Value**	**Reference**
Exposure dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_{plant}	COPEC concentration in plants (mg final COPEC/kg plant dry weight)	Calculated	See Equation 10
IR_{total}	Receptor-specific average ingestion rate based on total dietary intake (kg wet weight/day)	0.004	US EPA 1993b
IR_{plant}	Receptor-specific plant-matter ingestion rate (kg food wet weight/day)	0.003	Based on an average ingestion rate of 0.004 kg/day (US EPA, 1993b) and a diet of 74% plant matter (OEHHA, 1999)
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
C_{invert}	Invertebrate EPC (mg final COPEC/kg invertebrate dry weight)	Calculated	See Equation 11
IR_{invert}	Receptor-specific animal matter ingestion rate (kg food wet weight/day)	0.001	Based on an average ingestion rate of 0.004 kg/day (US EPA, 1993b) and a diet of 26% invertebrate matter (OEHHA, 1999)
C_{soil}	Surface-soil EPC (mg final COPEC/kg soil dry weight)	Site-specific	95% UCL if available, or maximum (0-0.5 ft bgs)
IR_{soil}	Receptor-specific incidental soil ingestion rate (kg soil dry weight/day)	0.000018	Based on < 2% (Beyer et. al, 1994); Average ingestion rate of (0.004

			kg/day wet weight * 0.22 ww:dw) * 2%.
ST	Bioavailability factor for constituents ingested in soil (assumed to be 1.0 for all constituents)	1.0	Conservative default (assume 100% bioavailability)
AUF	area use factor (maximum value = 1); ratio of area of site to average receptor foraging range (0.3 acres for deer mouse)	Site-specific	US EPA, 1993b
BW	average adult body weight (kg)	0.02	CDW, 2011

The equation and exposure assumptions that will be used to calculate the Tier 2 exposure doses for the horned lark are shown in Equation 13.

Equation 13. Calculation of Tier 2 Exposure Dose for COPECs in Soil; Horned Lark

$$Exposure\ Dose = \frac{\left[\left(C_{plant} \times \frac{IR_{plant}}{ww{:}\,dw}\right) + \left(C_{invert} \times \frac{IR_{invert}}{1/ww{:}\,dw}\right) + (C_{soil} \times IR_{soil} \times ST) \times AUF\right]}{BW}$$

Parameter	Definition (Units)	Value	Reference
Exposure dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_{plant}	COPEC concentration in plants (mg final COPEC/kg plant dry weight)	Calculated	See Equation 10
IR_{total}	Receptor-specific average ingestion rate based on total dietary intake (kg food wet weight/day)	0.035	US EPA 1993b; based on average ingestion rate for American robin adjusted for horned lark body weight.
IR_{plant}	Receptor-specific plant-matter ingestion rate (kg food wet weight/day)	0.026	Based on average ingestion rate of 0.035 kg/day (US EPA 1993b) and a diet of 75% plant matter (Doctor, *et* al, 2000) and US EPA, 1993b
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
C_{invert}	Invertebrate EPC (mg final COPEC / kg invertebrate dry weight)	Site-specific	See Equation 11
IR_{invert}	Receptor-specific animal matter ingestion rate (kg food wet weight/day)	0.009	Based on average ingestion rate of 0.035 kg/day (US EPA 1993b) and a diet of 25% invertebrates (Doctor, et al, 2000) and US EPA, 1993b
C_{soil}	Surface-soil EPC (mg final COPEC / kg soil dw)	Site-specific	95% UCL if available, or maximum (0-0.5 ft bgs)
IR_{soil}	Receptor-specific incidental soil ingestion rate	0.00077	Based on 10% (Baer, *et*

	(kg/day dry weight)		*al*, 1994). Average ingestion rate of (0.035 kg/day (wet weight) * 0.22 ww:dw) * 10%).
ST	Bioavailability factor for constituents ingested in soil (assumed to be 1 for all constituents)	1	Conservative default (assume 100% bioavailability)
AUF	Area use factor (maximum value = 1); ratio of area of site to average receptor foraging range (4 acres for horned lark)	Area of site (acres) / 4 acres	Beason, 1995
BW	Average adult body weight (kg)	0.033	Trost, 1972

The equation and exposure assumptions that will be used to calculate the Tier 2 exposure doses for the kit fox are shown in Equation 14.

Equation 14. Calculation of Tier 2 Exposure Dose for COPECs in Soil; Kit Fox

$$Exposure\ Dose = \frac{\left[\left(C_{prey} \times \frac{IR_{prey}}{1/ww{:}\,dw}\right) + (C_{soil} \times IR_{soil} \times ST) \times AUF\right]}{BW}$$

Parameter	Definition (Units)	Value	Reference
Exposure dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_{prey}	Prey EPC (mg final COPEC / kg prey dry weight)	Calculated	See Equation 11
IR_{prey}	Receptor-specific animal matter ingestion rate (kg food wet weight/day)	0.13	Based on an average ingestion rate of 0.13 kg/day (OEHHA, 2003) and a diet of 100% animal matter
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
C_{soil}	Surface and subsurface-soil (0-10 ft bgs) EPC (mg final COPEC / kg soil dw)	Site-specific	95% UCL if available, or maximum (0-10 ft bgs)
IR_{soil}	Receptor-specific incidental soil ingestion rate (kg soil dry weight/day)	0.0008	Based on 2.8% (Beyer et.al., 1994). Average ingestion rate of (0.13 kg/day (wet weight) *0.22 ww:dw) * 2.8%).
ST	Bioavailability factor for constituents ingested in soil (assumed to be 1for all constituents)	1	Conservative default (assume 100% bioavailability)
AUF	Area use factor (maximum value = 1); ratio of area of site to average receptor foraging range (1713 acres for kit fox)	Site-specific	--
BW	Average adult body weight (kg)	2.0	OEHHA, 2003

The equation and exposure assumptions that will be used to calculate the Tier 2 exposure doses for the red-tailed hawk are shown in Equation 15.

Equation 15. Calculation of Tier 2 Exposure Dose for COPECs in Soil; Red-Tailed Hawk

$$Exposure\ Dose = \frac{\left[\left(C_{prey} \times \frac{IR_{prey}}{1/ww{:}\,dw}\right) + (C_{soil} \times IR_{soil} \times ST) \times AUF\right]}{BW}$$

Parameter	Definition (Units)	Value	Reference
Exposure dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_{prey}	Prey EPC (mg final COPEC / kg prey dry weight)	Calculated	See Equation 11
IR_{prey}	receptor-specific animal matter ingestion rate (kg food wet weight/day)	0.1	Based on an average ingestion rate of 0.1 kg/day (US EPA 1993b) and a diet of 100% animal matter
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
C_{soil}	surface-soil EPC (mg final COPEC / kg soil dw)	Site-specific	95% UCL if available, or maximum (0-0.5 ft bgs)
IR_{soil}	receptor-specific incidental soil ingestion rate (kg soil dry weight/day)	0.0004	Based on < 2% (Beyer et. al., 1994). Average ingestion rate of (0.12 kg/day (wet weight) *0.22) * 2%).
ST	bioavailability factor for constituents ingested in soil (assumed to be 1 for all constituents)	1	Conservative default (assume 100% bioavailability)
AUF	area use factor (maximum value = 1); ratio of area of site to average receptor foraging range (1770 acres for red-tailed hawk)	Site-specific	--
BW	average adult body weight (kg)	1.1	US EPA, 1993b

The equation and exposure assumptions that will be used to calculate the Tier 2 exposure doses for the pronghorn are shown in Equation 16.

Equation 16. Calculation of Tier 2 Exposure Dose for COPECs in Soil; Pronghorn

$$Exposure\ Dose = \frac{\left[\left(C_{plant} \times \frac{IR_{plant}}{1/ww{:}dw}\right) + (C_{soil} \times IR_{soil} \times ST) \times AUF\right]}{BW}$$

Parameter	Definition (Units)	Value	Reference
Exposure dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_{plant}	COPEC concentration in plants (mg final COPEC/kg plant dry weight)	Calculated	See Equation 10
IR_{plant}	receptor-specific plant-matter ingestion rate (kg food wet weight/day)	1.4	Based on an average ingestion rate of 1.4 kg/day (US FWS, 2005) and a diet of 100% plant matter
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
C_{soil}	surface-soil EPC (mg final COPEC / kg soil dw)		95% UCL if available, or maximum (0-0.5 ft bgs)
IR_{soil}	receptor-specific incidental soil ingestion rate (kg soil dry weight/day)	0.006	Based on < 2% (Beyer et. al., 1994). Average ingestion rate of (1.4 kg/day (wet weight) * 0.22 ww:dw) * 2%).
ST	bioavailability factor for constituents ingested in soil (assumed to be 1.0 for all constituents)	1	Conservative default (assume 100% bioavailability)
AUF	area use factor (maximum value = 1); ratio of area of site to average receptor foraging range (3422 acres for pronghorn)	Site-specific	Zoellick & Smith, 1992
BW	Average adult body weight (kg)	50	O'Gara, 1978

4.1.1 Toxicity Assessment – Tier 2

The Tier 2 TRVs will be based on LOAELs. The LOAEL will be used as it is more representative of population risks.

4.1.2 Risk Characterization – Tier 2

Risk characterization for Tier 2 will be conducted by calculating HQs for plant and wildlife receptors using a similar method as in the Tier 1 SLERA. The equation and assumptions for calculating the Tier 2 HQs for wildlife receptors are shown in Equation 17.

Equation 17. Calculation of Tier 2 Hazard Quotients for Wildlife Receptors	
$$HQ = \frac{Dose}{TRV}$$	
Parameter	**Definition (Units)**
HQ	Hazard quotient (unitless)
Dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)
TRV	Toxicity reference value (mg/kg/day) based on lowest observed adverse effects level (LOAEL)

For plants, a qualitative discussion of the potential for adverse risk will be provided in the assessment. Comparison of TRVs to soil concentrations based on the 95% UCL may be provided.

Summation of HQs will be added for COPECs that have a similar receptor-specific mode of toxicity. If the Tier 2 HI is less than one, adverse ecological effects are not expected and no further action will be taken.

For sites that have an HI equal to or greater than one, the site may require: 1) additional evaluation under a weight-of-evidence analysis; 2) a Tier 3 ERA; or 3) a corrective measures study.

Per US EPA (1997c), Tier 2 ecological risk characterization should include a discussion of the uncertainties since many assumptions may or may not accurately reflect site conditions. Therefore, a discussion of the uncertainties associated with the Tier 2 SLERA will be included in the report.

5.0 TIER 3: PHASE II - QUANTITATIVE ASSESSMENT

In the event that the SLERA does not show that levels of contamination in the impacted media are below the target level of 1.0, additional quantitative analyses may be warranted. This may include incorporation of biota studies to evaluate impact at the site. NMED should be consulted prior to conducting a Tier 3 assessment.

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ATTACHMENT A
SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT
SCOPING ASSESSMENT
SITE ASSESSMENT CHECKLIST

INTRODUCTION

This checklist has been developed as a tool for gathering information about the facility property and surrounding areas, as part of the scoping assessment. Specifically, the checklist assists in the compilation of information on the physical and biological aspects of the site including the site environmental setting, usage of the site, releases at the site, contaminant fate and transport mechanisms, and the area's habitats, receptors, and exposure pathways. The completed checklist can then be used to construct the preliminary conceptual site exposure model (PCSEM) for the site. In addition, the checklist and PCSEM will serve as the basis for the scoping assessment report. Section III of this document provides further information on using the completed checklist to develop the PCSEM.

In general, the checklist is designed for applicability to all sites; however, there may be unusual circumstances which require professional judgment in order to determine the need for further ecological evaluation (*e.g.,* cave-dwelling receptors). In addition, some of the questions in the checklist may not be relevant to all sites. Some facilities may have large amounts of data available regarding contaminant concentrations and hydrogeologic conditions at the site, while other may have only limited data. In either case, the questions on the checklist should be addressed as completely as possible with the information available.

Habitats and receptors, which may be present at the site, can be identified by direct or indirect[36] observations and by contacting local and regional natural resource agencies. Habitat types may be determined by reviewing land use and land cover maps (LULC), which are available via the Internet at http://www.nationalatlas.gov/mapit.html. With regard to receptors, it should be noted that receptors are often present at a site even when they are not observed. Therefore, for the purposes of this checklist, it should be assumed that receptors are present if viable habitat is present. The presence of receptors should be confirmed by contacting one or several of the organizations listed below.

Sources of general information available for the identification of ecological receptors and habitats include:

- U.S. Fish and Wildlife Service (http://www.fws.gov)
- Biota Information System of New Mexico (BISON-M) maintained by the New Mexico Department of Game and Fish (NMGF) (http://151.199.74.229/states/nm.htm)
- U.S. Forest Service (USFS) (http://www.fs.fed.us/)
- New Mexico Forestry Division (NMFD) of the Energy, Minerals and Natural Resources Department (http://www.emnrd.state.nm.us/forestry/index.htm)
- U.S. Bureau of Land Management (USBLM) (http://www.blm.gov/nhp/index.htm) or (http://www.nm.blm.gov/www/new_home_2.html)
- United States Geological Service (USGS) (http://www.usgs.gov)

36 Examples of indirect observations that indicate the presence of receptors include: tracks, feathers, burrows, scat

- National Wetland Inventory Maps (http://wetlands.fws.gov)
- National Audubon Society (http://www.audobon.com)
- National Biological Information Infrastructure (http://biology.usgs.gov)
- Sierra Club (http://www.sierraclub.org)
- National Geographic Society (http://www.nationalgeographic.com)
- New Mexico Natural Heritage Program (http://nmnhp.unm.edu/)
- State and National Parks System
- Local universities
- Tribal organizations

INSTRUCTIONS FOR COMPLETING THE CHECKLIST

The checklist consists of four sections: Site Location, Site Characterization, Habitat Evaluation, and Exposure Pathway Evaluation. Answers to the checklist should reflect existing conditions and should not consider future remedial actions at the site. Completion of the checklist should provide sufficient information for the preparation of a PCSEM and scoping report and allow for the identification of any data gaps.

Section I - Site Location, provides general site information, which identifies the facility being evaluated, and gives specific location information. Site maps and diagrams, which should be attached to the completed checklist, are an important part of this section. The following elements should be clearly illustrated: 1) the location and boundaries of the site relative to the surrounding area, 2) any buildings, structures or important features of the facility or site, and 3) all ecological areas or habitats identified during completion of the checklist. It is possible that several maps will be needed to clearly and adequately illustrate the required elements. Although topographical information should be illustrated on at least one map, it is not required for every map. Simplified diagrams (preferably to scale) of the site and surrounding areas will usually suffice.

Section II - Site Characterization, is intended to provide additional temporal and contextual information about the site, which may have an impact on determining whether a certain area should be characterized as ecologically viable habitat or contains receptors. Answers to the questions in Section II will help the reviewer develop a broader and more complete evaluation of the ecological aspects of a site.

Section III - Habitat Evaluation, provides information regarding the physical and biological characteristics of the different habitat types present at or in the locality of the site. Aquatic features such as lakes, ponds, streams, arroyos and ephemeral waters can be identified by reviewing aerial photographs, LULC and topographic maps and during site reconnaissance visits. In New Mexico, there are several well-defined terrestrial communities, which occur naturally. Typical communities include wetlands, forest (e.g., mixed conifer, ponderosa pine and pinyon juniper), scrub/shrub, grassland, and desert. Specific types of vegetation characterize each of these communities and can be used to identify them. Field guides are often useful for identifying vegetation types. A number of sites may be in areas that have been disturbed by human activities and may no longer match any of the naturally occurring communities typical of the southwest.

Particularly at heavily used areas at facilities, the two most common of these areas are usually described as "weed fields" and "lawn grass". Vegetation at "weed fields" should be examined to determine whether the weeds consist primarily of species native to the southwest or introduced species such as Kochia. Fields of native weeds and lawn grass are best evaluated using the short grass prairie habitat guides.

The applicable portions of Section III of the checklist should be completed for each individual habitat identified. For example, the questions in Section III.A of the checklist should be answered for each wetland area identified at or in the locality of the site and the individual areas must be identified on a map or maps.

Section IV- Exposure Pathway Evaluation is used to determine if contaminants at the site have the potential to impact habitat identified in Section III. An exposure pathway is the course a chemical or physical agent takes from a source to an exposed organism. Each exposure pathway includes a source (or release from a source), an environmental transport mechanism, an exposure point, and an exposure route. A complete exposure pathway is one in which each of these components, as well as a receptor to be exposed, is present. Essentially, this section addresses the fate and transport of contaminants that are known or suspected to have been released at the site. In most cases, without a complete exposure pathway between contaminants and receptors, additional ecological evaluation is not warranted.

Potential transport pathways addressed in this checklist include migration of contaminants via air dispersion, leaching into groundwater, soil erosion/runoff, groundwater discharge to surface water, and irradiation. Due to New Mexico's semi-arid climate, vegetation is generally sparse. The sparse vegetation, combined with the intense nature of summer storms in New Mexico, results in soil erosion that occurs sporadically over a very brief time frame. Soil erosion may be of particular concern for sites located in steeply sloped areas. Several questions within Section IV of this checklist have been developed to aid in the identification of those sites where soil erosion/runoff would be an important transport mechanism.

USING THE CHECKLIST TO DEVELOP THE PRELIMINARY CONCEPTUAL SITE EXPOSURE MODEL

The completed Site Assessment Checklist can be used to construct the PCSEM. An example PCSEM diagram is presented in Figure 1. The CSM illustrates actual and potential contaminant migration and exposure pathways to associated receptors. The components of a complete exposure pathway are simplified and grouped into three main categories: sources, release mechanisms, and potential receptors. As a contaminant migrates and/or is transformed in the environment, sources and release mechanisms may expand into primary, secondary, and tertiary levels. For example, Figure 1 illustrates releases from inactive lagoons (primary sources) through spills (primary release mechanism), which migrate to surface and subsurface soils (secondary sources), which are then leached (secondary release mechanism) to groundwater (tertiary source). Similarly, exposures of various trophic levels to the contaminant(s) and consequent exposures via the food chain may lead to multiple groups of receptors. For example, Figure 1 illustrates groups of both aquatic and terrestrial receptors which may be exposed and subsequently serve as tertiary release mechanisms to receptors which prey on them.

Although completing the checklist will not provide the user with a readymade PCSEM, a majority of the components of the PCSEM can be found in the answers to the checklist. It is then up to the user to put the pieces together into a comprehensive whole. The answers from Section II of the checklist, Site Characterization, can be used to identify sources of releases. The answers to Section IV, Exposure Pathway Evaluation, will assist users in tracing the migration pathways of releases in the environment, thus helping to identify release mechanisms and sources. The results of Section III, Habitat Evaluation, can be used to both identify secondary and tertiary sources and to identify the types of receptors which may be exposed. Appendix B of the NMED's *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Assessment* also contains sample food webs which may be used to develop the PCSEM.

Once all of the components have been identified, one can begin tracing the steps between the primary releases and the potential receptors. For each potential receptor, the user should consider all possible exposure points (e.g., prey items, direct contact with contaminated soil or water, etc.) then begin eliminating pathways, which are not expected to result in exposure to the contaminant at the site. Gradually, the links between the releases and receptors can be filled in, resulting in potential complete exposure pathways.

For further guidance on constructing a PCSEM, consult the NMED's *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Assessment* (2000), and EPA's Office of Solid Waste and Emergency *Response's Soil Screening Guidance: User's Guide* (1996).

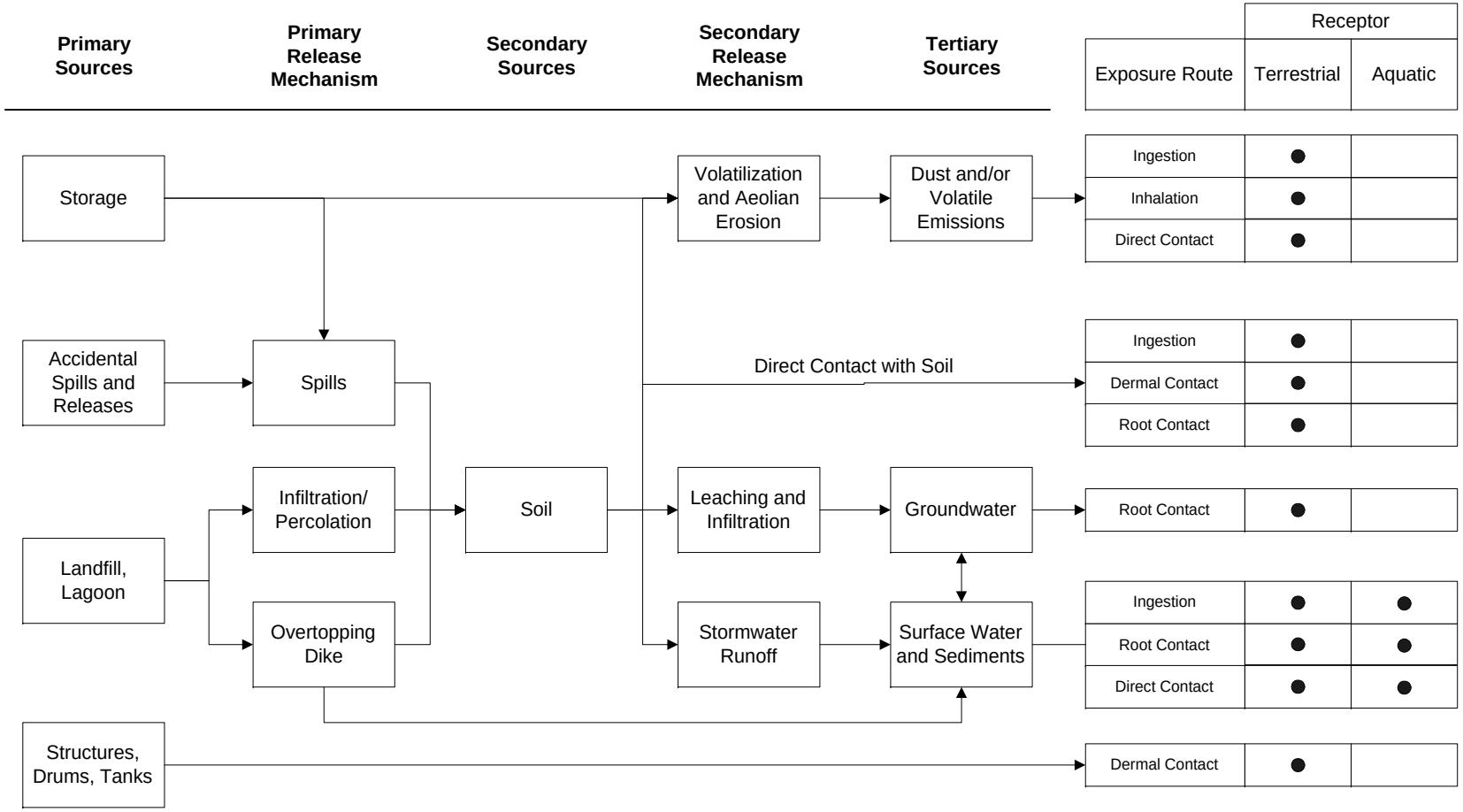

Figure 1. Example Preliminary Conceptual Site Exposure Model Diagram

NEW MEXICO ENVIRONMENT DEPARTMENT
SITE ASSESSMENT CHECKLIST

I. SITE LOCATION

1. Site
   Name:_____
   US EPA I.D.
   Number:_____
   Location:_____
   County:_____
   City:_____State:_____

2. Latitude:_____ Longitude:_____

3. Attach site maps, including a topographical map, a diagram which illustrates the layout of the facility (e.g., site boundaries, structures, etc.), and maps showing all habitat areas identified in Section III of the checklist. Also, include maps which illustrate known release areas, sampling locations, and any other important features, if available.

II. SITE CHARACTERIZATION

1. Indicate the approximate area of the site (i.e., acres or sq. ft)
   _____

2. Provide an approximate breakdown of the land uses on the site:

_____% Heavy Industrial	_____% Light Industrial	_____% Urban
_____% Residential	_____% Rural	_____% Agricultural[b]
_____% Recreational[a]	_____% Undisturbed	_____% Other[c]

[a]For recreational areas, please describe the usage of the area (e.g., park, playing field, etc.):
_____

[b]For agricultural areas, please list the crops and/or livestock which are present:
_____

[c]For areas designated as "other", please describe the usage of the area:
_____

3. Provide an approximate breakdown of the land uses in the area surrounding the site. Indicate the radius (in miles) of the area described: _____

_____% Heavy Industrial	_____% Light Industrial	_____% Urban
_____% Residential	_____% Rural	_____% Agricultural[b]
_____% Recreational[a]	_____% Undisturbed	_____% Other [c]

[a]For recreational areas, please describe the usage of the area (e.g., park, playing field, golf course, etc.):

_____

[b]For agricultural areas, please list the crops and/or livestock which are present:

_____

[c]For areas designated as "other", please describe the usage of the area:

_____

_____

4. Describe reasonable and likely future land and/or water use(s) at the site.

_____

_____

_____

_____

_____

_____

5. Describe the historical uses of the site. Include information on chemical releases that may have occurred as a result of previous land uses. For each chemical release, provide information on the form of the chemical released (i.e., solid, liquid, vapor) and the known or suspected causes or mechanism of the release (i.e., spills, leaks, material disposal, dumping, explosion, etc.).

_____

_____

_____

_____

_____

6. If any movement of soil has taken place at the site, describe the degree of the disturbance. Indicate the likely source of any disturbances (e.g., erosion, agricultural, mining, industrial activities, removals, etc.) and estimate when these events occurred.

_____

_____

_____

7. Describe the current uses of the site. Include information on recent (previous 5 years) disturbances or chemical releases that have occurred. For each chemical release, provide information on the form of the chemical released and the causes or mechanism of the release.

_____
_____
_____
_____
_____

8. Identify the location or suspected location of chemical releases at the site. Provide an estimate of the distance between these locations and the areas identified in Section III.

_____
_____
_____
_____
_____

9. Identify the suspected contaminants of concern (COCs) at the site. If known, include the maximum contaminant levels. Please indicate the source of data cited (e.g., RFI, confirmatory sampling, etc.).

_____
_____
_____
_____
_____
_____
_____

10. Identify the media (e.g., soil (surface or subsurface), surface water, air, groundwater) which are known or suspected to contain COCs._____
_____

11. Indicate the approximate depth to groundwater (in feet below ground surface [(bgs)].

_____

12. Indicate the direction of groundwater flow (e.g., north, southeast, etc.)

_____

III. HABITAT EVALUATION

III.A Wetland Habitats

Are any wetland[37] areas such as marshes or swamps on or adjacent to the site?

☐ Yes ☐ No

If yes, indicate the wetland area on the attached site map and answer the following questions regarding the wetland area. If more than one wetland area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual wetland area. Distinguish between wetland areas by using names or other designations (such as location), and clearly identify each area on the site map. Also, obtain and attach a National Wetlands Inventory Map (or maps) to illustrate each wetland area.

Identify the sources of the observations and information (e.g., National Wetland Inventory, Federal or State Agency, USGS topographic maps) used to make the determination that wetland areas are or are not present.

_____
_____
_____
_____

If no wetland areas are present, proceed to Section III.B.

Wetland Area Questions

☐ Onsite ☐ Offsite

Name or Designation:_____

1. Indicate the approximate area of the wetland (acres or ft^2)_____

2. Identify the type(s) of vegetation present in the wetland.

- ❑ Submergent (i.e., underwater) vegetation
- ❑ Emergent (i.e., rooted in the water, but rising above it) vegetation
- ❑ Floating vegetation
- ❑ Scrub/shrub

37Wetlands are defined in 40 CFR §232.2 as " Areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Examples of typical wetlands plants include: cattails, cordgrass, willows and cypress trees. National wetland inventory maps may be available at http:\\nwi.fws.gov. Additional information on wetland delineation criteria is also available from the Army Corps of Engineers.

- ❑ Wooded
- ❑ Other (Please describe):_____

3. Estimate the vegetation density of the wetland area.

- ❑ Dense (i.e., greater than 75% vegetation)
- ❑ Moderate (i.e., 25% to 75% vegetation)
- ❑ Sparse (i.e., less than 25% vegetation)

4. Is standing water present? ☐ Yes ☐ No

   If yes, is the water primarily: ☐ Fresh or ☐ Brackish
   Indicate the approximate area of the standing water (ft^2):
   _____
   Indicate the approximate depth of the standing water, if known (ft. or in.)_____

5. If known, indicate the source of the water in the wetland.

- ❑ Stream/River/Creek/Lake/Pond
- ❑ Flooding
- ❑ Groundwater
- ❑ Surface runoff

6. Is there a discharge from the facility to the wetland? ☐ Yes ☐ No
   If yes, please describe:_____
   _____
   _____
   _____
   _____
   _

Wetland Area Questions (Continued)

7. Is there a discharge from the wetland? ☐ Yes ☐ No
If yes, indicate the type of aquatic feature the wetland discharges into:

- ❑ Surface stream/River (Name:_____)
- ❑ Lake/Pond (Name:_____)
- ❑ Groundwater
- ❑ Not sure

8. Does the area show evidence of flooding? ☐ Yes ☐ No
If yes, indicate which of the following are present (mark all that apply):

- ❑ Standing water
- ❑ Water-saturated soils
- ❑ Water marks
- ❑ Buttressing
- ❑ Debris lines
- ❑ Mud cracks
- ❑ Other (Please describe):_____

9. Animals observed in the wetland area or suspected to be present based on indirect evidence or file material:

- ❑ Birds
- ❑ Fish
- ❑ Mammals
- ❑ Reptiles (e.g., snakes, turtles)
- ❑ Amphibians (e.g., frogs, salamanders)
- ❑ Sediment-dwelling invertebrates (e.g., mussels, crayfish, insect nymphs)

Specify species, if known:

_____
_____
_____
_____

III.B Aquatic Habitats
III.B.1 Non-Flowing Aquatic Features

Are any non-flowing aquatic features (such as ponds or lakes) located at or adjacent to the site?

☐ Yes ☐ No

If yes, indicate the aquatic feature on the attached site map and answer the following questions regarding the non-flowing aquatic features. If more than one non-flowing aquatic feature is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual aquatic feature. Distinguish between aquatic features by using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.B.2.

Non-Flowing Aquatic Feature Questions

☐ Onsite ☐ Offsite

Name or Designation:_____

1. Indicate the type of aquatic feature present:

   - ❑ Natural (e.g., pond or lake)
   - ❑ Man-made (e.g., impoundment, lagoon, canal, etc.)

2. Estimate the approximate size of the water body (in acres or sq. ft.)_____

3. If known, indicate the depth of the water body (in ft. or in.)._____

Non-Flowing Aquatic Feature Questions (Continued)

4. Indicate the general composition of the bottom substrate. Mark all sources that apply from the following list.

☐ Bedrock	☐ Sand	☐ Concrete
☐ Boulder (>10 in.)	☐ Silt	☐ Debris
☐ Cobble (2.5 - 10 in.)	☐ Clay	☐ Detritus
☐ Gravel (0.1 - 2.5 in.)	☐ Muck (fine/black)	

☐ Other (please specify):_____

5. Indicate the source(s) of the water in the aquatic feature. Mark all sources that apply from the following list.

- ☐ River/Stream/Creek
- ☐ Groundwater
- ☐ Industrial Discharge
- ☐ Surface Runoff
- ☐ Other (please specify):_____

6. Is there a discharge from the facility to the aquatic feature? ☐ Yes ☐ No

If yes, describe the origin of each discharge and its migration path:

_____
_____
_____
_____

7. Does the aquatic feature discharge to the surrounding environment? ☐ Yes ☐ No

If yes, indicate the features from the following list into which the aquatic feature discharges, and indicate whether the discharge occurs onsite or offsite:

- ☐ River/Stream/Creek ☐ onsite ☐ offsite
- ☐ Groundwater ☐ onsite ☐ offsite
- ☐ Wetland ☐ onsite ☐ offsite
- ☐ Impoundment ☐ onsite ☐ offsite
- ☐ Other (please describe)_____

Non-Flowing Aquatic Feature Questions (Continued)

8. Animals observed in the vicinity of the aquatic feature or suspected to be present based on indirect evidence or file material:

- ❑ Birds
- ❑ Fish
- ❑ Mammals
- ❑ Reptiles (e.g., snakes, turtles)
- ❑ Amphibians (e.g., frogs, salamanders)
- ❑ Sediment-dwelling invertebrates (e.g., mussels, crayfish, insect nymphs)

Specify species, if known:

_____
_____
_____
_____

III.B.2 Flowing Aquatic Features

Are any flowing aquatic features (such as streams or rivers) located at or adjacent to the site?

☐ Yes ☐ No

If yes, indicate the aquatic feature on the attached site map and answer the following questions regarding the flowing aquatic features. If more than one flowing aquatic feature is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual aquatic feature. Distinguish between aquatic features by using names or other designations, and clearly identify each area on the site map

If no, proceed to Section III.C.

Flowing Aquatic Feature Questions

☐ Onsite ☐ Offsite

Name or Designation:_____

1. Indicate the type of flowing aquatic feature present.

   - ❑ River
   - ❑ Stream
   - ❑ Creek
   - ❑ Brook
   - ❑ Dry wash
   - ❑ Arroyo
   - ❑ Intermittent stream
   - ❑ Artificially created (ditch, etc.)
   - ❑ Other (specify)
   - ❑

2. Indicate the general composition of the bottom substrate.

☐ Bedrock	☐ Sand	☐ Concrete
☐ Boulder (>10 in.)	☐ Silt	☐ Debris
☐ Cobble (2.5 - 10 in.)	☐ Clay	☐ Detritus
☐ Gravel (0.1 - 2.5 in.)	☐ Muck (fine/black)	

☐ Other (please specify):_____

3. Describe the condition of the bank (e.g., height, slope, extent of vegetative cover) of the aquatic feature.

_____
_____
_____
_____

4. Is there a discharge from the facility to the aquatic feature? ☐ Yes ☐ No
   If yes, describe the origin of each discharge and its migration path:

_____
_____
_____
_____

5. Indicate the discharge point of the water body. Specify name, if known.

Flowing Aquatic Feature Questions (Continued)

6. If the flowing aquatic feature is a dry wash or arroyo, answer the following questions.
   - ❑Check here if feature is not a dry wash or arroyo

   If known, specify the average number of days in a year in which flowing water is present in the feature: _____

   Is standing water or mud present? Check all that apply.
   - ❑Standing water
   - ❑Mud
   - ❑Neither standing water or mud

   Does the area show evidence of recent flow (e.g., flood debris clinging to vegetation)?
   - ❑Yes
   - ❑No
   - ❑Not sure
7. Animals observed in the vicinity of the aquatic feature or suspected to be present based on indirect evidence or file material:

   - ❑ Birds
   - ❑ Fish
   - ❑ Mammals
   - ❑ Reptiles (e.g., snakes, turtles)
   - ❑ Amphibians (e.g., frogs, salamanders)
   - ❑ Sediment-dwelling invertebrates (e.g., mussels, crayfish, insect nymphs)

   Specify species, if known:

   _____
   _____
   _____
   _____

III.C Terrestrial Habitats
III.C.1 Wooded

Are any wooded areas on or adjacent to the site? ☐ Yes ☐ No

If yes, indicate the wooded area on the attached site map and answer the following questions. If more than one wooded area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual wooded area. Distinguish between wooded areas by using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.C.2.

Wooded Area Questions

☐ On-site ☐ Off-site

Name or Designation:_____

1. Estimate the approximate size of the wooded area (in acres or sq. ft.)_____

2. Indicate the dominant type of vegetation in the wooded area.

   - ❑ Evergreen
   - ❑ Deciduous
   - ❑ Mixed

   Dominant plant species, if known:_____

3. Estimate the vegetation density of the wooded area.

   ❑Dense (i.e., greater than 75% vegetation)
   ❑Moderate (i.e., 25% to 75% vegetation)
   ❑Sparse (i.e., less than 25% vegetation)

4. Indicate the predominant size of the trees at the site. Use diameter at chest height.

   - ❑ 0-6 inches
   - ❑ 6-12 inches
   - ❑ >12 inches
   - ❑ No single size range is predominant

5. Animals observed in the wooded area or suspected to be present based on indirect evidence or file material:

   - ❑ Birds
   - ❑ Mammals
   - ❑ Reptiles (e.g., snakes, lizards)
   - ❑ Amphibians (e.g., toads, salamanders)

   Specify species, if known:
   _____
   _____
   _____
   _____

III.C.2 Shrub/Scrub

Are any shrub/scrub areas on or adjacent to the site? ☐ Yes ☐ No

If yes, indicate the shrub/scrub area on the attached site map and answer the following questions. If more than one shrub/scrub area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual shrub/scrub area. Distinguish between shrub/scrub areas, using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.C.3.

Shrub/Scrub Area Questions

☐ Onsite ☐ Offsite

Name or Designation:_____

1. Estimate the approximate size of the shrub/scrub area (in acres or sq. ft.)._____

2. Indicate the dominant type of shrub/scrub vegetation present, if known.

_____
_____
_____
_____

3. Estimate the vegetation density of the shrub/scrub area.

   - ❑ Dense (i.e., greater than 75% vegetation)
   - ❑ Moderate (i.e., 25% to 75% vegetation)
   - ❑ Sparse (i.e., less than 25% vegetation)

4. Indicate the approximate average height of the scrub/shrub vegetation.

   - ❑ 0-2 feet
   - ❑ 2-5 feet
   - ❑ >5 feet

5. Animals observed in the shrub/scrub area or suspected to be present based on indirect evidence or file material:

   ❑Birds
   ❑Mammals
   ❑Reptiles (e.g., snakes, lizards)
   ❑Amphibians (e.g., toads, salamanders)

   Specify species, if known:

   _____
   _____
   _____
   _____

III.C.3 Grassland

Are any grassland areas on or adjacent to the site? ☐ Yes ☐ No

If yes, indicate the grassland area on the attached site map and answer the following questions. If more than one grassland area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual grassland area. Distinguish between grassland areas by using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.C.4.

Grassland Area Questions

☐ Onsite ☐ Offsite

Name or Designation:_____

1. Estimate the approximate size of the grassland area (in acres or sq. ft.)._____

2. Indicate the dominant plant type, if known.

_____
_____
_____
_____

3. Estimate the vegetation density of the grassland area.

   - ❑ Dense (i.e., greater than 75% vegetation)
   - ❑ Moderate (i.e., 25% to 75% vegetation)
   - ❑ Sparse (i.e., less than 25% vegetation)

4. Indicate the approximate average height of the dominant plant type (in ft. or in.)_

5. Animals observed in the grassland area or suspected to be present based on indirect evidence or file material:

   ❑Birds
   ❑Mammals
   ❑Reptiles (e.g., snakes, lizards)
   ❑Amphibians (e.g., toads, salamanders)

   Specify species, if known:

III.C.4 Desert

Are any desert areas on or adjacent to the site? ☐ Yes ☐ No

If yes, indicate the desert area on the attached site map and answer the following questions. If more than one desert area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual desert area. Distinguish between desert areas by using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.C.5.

Desert Area Questions

☐ Onsite ☐ Offsite

Name or Designation:_____

1. Estimate the approximate size of the desert area (in acres or sq. ft.)._____

2. Describe the desert area (e.g., presence or absence of vegetation, vegetation types, presence/size of rocks, sand, etc.)

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

3. Animals observed in the desert area or suspected to be present based on indirect evidence or file material:

❑Birds
❑Mammals
❑Reptiles (e.g., snakes, lizards)
❑Amphibians (e.g., toads, salamanders)

Specify species, if known:

_____

III.C.5 Other

1. Are there any other terrestrial communities or habitats on or adjacent to the site which were not previously described?

☐ Yes ☐ No

If yes, indicate the "other" area(s) on the attached site map and describe the area(s) below. Distinguish between onsite and offsite areas. If no, proceed to Section III.D.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

III.D Sensitive Environments and Receptors

1. Do any other potentially sensitive environmental areas[38] exist adjacent to or within 0.5 miles of the site? If yes, list these areas and provide the source(s) of information used to identify sensitive areas. *Do not answer "no" without confirmation from the U.S. Fish and Wildlife Service and appropriate State of New Mexico division.*

_____
_____
_____
_____
_____
_____
_____
_____

3 Areas that provide unique and often protected habitat for wildlife species. These areas are typically used during critical life stages such as breeding, hatching, rearing of young and overwintering. Refer to **Table 1** at the end of this document for examples of sensitive environments.

2. Are any areas on or near (i.e., within 0.5 miles) the site which are owned or used by local tribes? If yes, describe. *Contact the Tribal Liaison in the Office of the Secretary (505)827-2855 to obtain this information.*

_____
_____
_____
_____
_____

4. Does the site serve or potentially serve as a habitat, foraging area, or refuge by rare, threatened, endangered, candidate and/or proposed species (plants or animals), or any otherwise protected species? If yes, identify species. *This information should be obtained from the U.S. Fish and Wildlife Service and appropriate State of New Mexico division.*

_____
_____
_____
_____
_____
_____
_____

5. Is the site potentially used as a breeding, roosting or feeding area by migratory bird species? If yes, identify which species.

_____
_____
_____
_____
_____

6. Is the site used by any ecologically[39], recreationally, or commercially important

39 Ecologically important species include populations of species which provide a critical (i.e., not replaceable) food resource for higher organisms and whose function as such would not be replaced by more tolerant species; or perform a critical ecological function (such as organic matter decomposition) and whose functions will not be replaced by other species. Ecologically important species include pest and opportunistic species that populate an area <u>if they serve as a food source for other species</u>, but do <u>not</u> include domesticated animals (e.g., pets and livestock) or plants/animals whose existence is maintained by continuous human interventions (e.g., fish hatcheries, agricultural crops, etc.,)

species? If yes, explain.

_____
_____
_____
_____
_____

IV. EXPOSURE PATHWAY EVALUATION

1. Do existing data provide sufficient information on the nature, rate, and extent of contamination at the site?

   - ❑ Yes
   - ❑ No
   - ❑ Uncertain

   Please provide an explanation for your answer:_____

_____
_____
_____
_____

2. Do existing data provide sufficient information on the nature, rate, and extent of contamination in offsite affected areas?

   - ❑ Yes
   - ❑ No
   - ❑ Uncertain
   - ❑ No offsite contamination

   Please provide an explanation for your answer:_____

_____
_____
_____
_____

3. Do existing data address potential migration pathways of contaminants at the site?

   - ❑ Yes
   - ❑ No
   - ❑ Uncertain

Please provide an explanation for your answer:_____
_
_____
_____
_____
_____

4. Do existing data address potential migration pathways of contaminants in offsite affected areas?

   - ❑ Yes
   - ❑ No
   - ❑ Uncertain
   - ❑ No offsite contamination

   Please provide an explanation for your answer:_____

_____
_____
_____
_____

5. Are there visible indications of stressed habitats or receptors on or near (i.e., within 0.5 miles) the site that may be the result of a chemical release? If yes, explain. Attach photographs if available.

_____
_____
_____
_____
_____
_____

6. Is the location of the contamination such that receptors might be reasonably expected to come into contact with it? For soil, this means contamination in the soil 0 to 5 feet below ground surface (bgs). If yes, explain.

_____
_____
_____
_____
_____
_____
_____

7. Are receptors located in or using habitats where chemicals exist in air, soil, sediment or surface water? If yes, explain.

_____
_____
_____
_____
_____

8. Could chemicals reach receptors via groundwater? Can chemicals leach or dissolve to groundwater? Are chemicals mobile in groundwater? Does groundwater discharge into receptor habitats? If yes, explain.

_____
_____
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_____
_____

9. Could chemicals reach receptors through runoff or erosion? Answer the following questions:

What is the approximate distance from the contaminated area to the nearest watercourse or arroyo?

- ❑ 0 feet (i.e., contamination has reached a watercourse or arroyo)
- ❑ 1-10 feet
- ❑ 11-20 feet
- ❑ 21-50 feet
- ❑ 51-100 feet
- ❑ 101-200 feet
- ❑ > 200 feet
- ❑ > 500 feet
- ❑ > 1000 feet

What is the slope of the ground in the contaminated area?

- ❑ 0-10%
- ❑ 10-30%
- ❑ > 30%

What is the approximate amount of ground and canopy vegetative cover in the contaminated area?

- ❑ < 25%
- ❑ 25-75%
- ❑ > 75%

Is there visible evidence of erosion (e.g., a rill or gully) in or near the contaminated area?

- ❑ Yes
- ❑ No
- ❑ Do not know

Do any structures, pavement, or natural drainage features direct run-on flow (i.e., surface flows originating upstream or uphill from the area of concern) into the contaminated area?

- ❑ Yes
- ❑ No
- ❑ Do not know

10. Could chemicals reach receptors through the dispersion of contaminants in air (e.g., volatilization, vapors, fugitive dust)? If yes, explain.

_____
_____
_____
_____
_____
_____

11. Could chemicals reach receptors through migration of non-aqueous phase liquids (NAPLs)? Is a NAPL present at the site that might be migrating towards receptors or habitats? Could NAPL discharge contact receptors or their habitat?

_____
_____
_____
_____
_____
_____
_____

12. Could receptors be impacted by external irradiation at the site? Are gamma emitting radionuclides present at the site? Is the radionuclide contamination buried or at the surface?

_____
_____
_____
_____
_____
_____
_____

PHOTOGRAPHIC DOCUMENTATION

During the site visit(s), photographs should be taken to document the current conditions at the site and to support the information entered in the checklist. For example, photographs may be used to document the following:

- The nature, quality, and distribution of vegetation at the site
- Receptors or evidence of receptors
- Potentially important ecological features, such as ponds and drainage ditches
- Potential exposure pathways
- Any evidence of contamination or impact

The following space may be used to record photo subjects.

_____
_____
_____
_____
_____
_____
_____
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SUMMARY OF OBSERVATIONS AND SITE SETTING

Include information on significant source areas and migration pathways that are likely to constitute complete exposure pathways.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
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_____
_____

Checklist Completed by_____

Affiliation_____

Author Assisted by_____

Date_____

TABLE 1
EXAMPLES OF SENSITIVE ENVIRONMENTS

National Parks and National Monuments

Designated or Administratively Proposed Federal Wilderness Areas

National Preserves

National or State Wildlife Refuges

National Lakeshore Recreational Areas

Federal land designated for protection of natural ecosystems

State land designated for wildlife or game management

State designated Natural Areas

Federal or state designated Scenic or Wild River

All areas that provide or could potentially provide critical habitat[1] for state and federally listed Threatened or Endangered Species, those species that are currently petitioned for listing, and species designated by other agencies as sensitive or species of concern

All areas that provide or could potentially provide habitat for state protected species as defined in the Wildlife Code, Chapter 17 of the New Mexico Statutes

All areas that provide or could potentially provide habitat for migratory birds as protected by the Migratory Bird Treaty Act (16 U.S.C. §§ 703-712)

All areas that provide or could potentially provide habitat for bald eagles and golden eagles as protected by the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d)

All areas that provide or could potentially provide habitat for song birds as protected by the State of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-13)

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1 Critical habitats are defined by the Endangered Species Act (50 CFR §424.02(d)) as:

> 1) Specific areas within the geographical area currently occupied by a species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species and (ii) that may require special management considerations or protection, and 2) Specific areas outside the geographical area occupied by a species at the time it is listed upon a determination by the Secretary [of Interior] that such areas are essential for the conservation of the species.

All areas that provide or could potentially provide habitat for hawks, vultures and owls as protected by the State of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-14)

All areas that provide or could potentially provide habitat for horned toads and Bullfrogs as protected by the State of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-15 and 16, resp.)

All perennial waters (e.g., rivers, lakes, playas, sloughs, ponds, etc)

All ephemeral drainage (e.g., arroyos, puddles/pools, intermittent streams, etc) that provide significant wildlife habitat or that could potentially transport contaminants off site to areas that provide wildlife habitat

All riparian habitats

All perennial and ephemeral wetlands (not limited to jurisdictional wetlands)

All areas that are potentially important breeding, staging, and overwintering habitats as well as other habitats important for the survival of animals during critical periods of their life cycle.

ATTACHMENT B
ECOLOGICAL SITE EXCLUSION CRITERIA CHECKLIST AND DECISION TREE

NEW MEXICO ECOLOGICAL EXCLUSION CRITERIA CHECKLIST

The following questions are designed to be used in conjunction with the Ecological Exclusion Criteria Decision Tree (Figure 1). After answering each question, refer to the Decision Tree to determine the appropriate next step. In some cases, questions will be omitted as the user is directed to another section as indicated by the flow diagram in the Decision Tree. For example, if the user answers "yes" to Question 1 of Section I, he or she is directed to proceed to Section II.

I. Habitat

In the following questions, "affected property" refers to all property on which a release has occurred or is believed to have occurred, including off-site areas where contamination may have occurred or migrated.

1. Are any of the below-listed sensitive environments at, adjacent to, or in the locality[1] of the affected property?

   - National Park or National Monument
   - Designated or administratively proposed Federal Wilderness Area
   - National Preserve
   - National or State Wildlife Refuge
   - Federal or State land designated for wildlife or game management
   - State designated Natural Areas
   - All areas that are owned or used by local tribes
   - All areas that are potentially important breeding, staging, and overwintering habitats as well as other habitats important for the survival of animals during critical periods of their life cycle
   - All areas that provide or could potentially provide habitat for state and federally listed Threatened or Endangered Species, those species that are currently petitioned for listing, and species designated by other agencies as sensitive or species of concern
   - All areas that provide or could potentially provide habitat for state protected species as defined in the Wildlife Code, Chapter 17 of the New Mexico Statutes
   - All areas that provide or could potentially provide habitat for migratory birds as protected by the Migratory Bird Treaty Act (16 U.S.C. §§ 703-712)
   - All areas that provide or could potentially provide habitat for bald eagles and golden eagles as protected by the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d)
   - All areas that provide or could potentially provide habitat for song birds as protected by the state of New Mexico statute (New Mexico Statute, 1978, Chapter

1 *Locality* of the site refers to any area where an ecological receptor is likely to contact site-related chemicals. The locality of the site considers the likelihood of contamination migrating over time and places the site in the context of its general surrounding. Therefore, the locality is typically larger than the site and the areas adjacent to the site.

17, Game and Fish, 17-2-13)

- All areas that provide or could potentially provide habitat for hawks, vultures and owls as protected by the state of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-14)
- All areas that provide or could potentially provide habitat for horned toads and bullfrogs as protected by the state of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-15 and 16, respectively)

2. Does the affected property contain land areas which were not listed in Question 1, but could be considered viable ecological habitat? The following are examples (but not a complete listing) of viable ecological habitats:

- Wooded areas
- Shrub/scrub vegetated areas
- Open fields (prairie)
- Other grassy areas
- Desert areas
- Any other areas which support wildlife and/or vegetation, excluding areas which support only opportunistic species (such as house mice, Norway rats, pigeons, etc.) that do not serve as prey to species in adjacent habitats.

The following features are <u>not</u> considered ecologically viable:

- Pavement
- Buildings
- Paved areas of roadways
- Paved/concrete equipment storage pads
- Paved manufacturing or process areas
- Other non-natural surface cover or structure

3. Does the affected property contain any perennial or ephemeral aquatic features which were not listed in Question 1?

II. Receptors

1. Is any part of the affected property used for habitat, foraging area, or refuge by any rare, threatened, or endangered species (plant *or* animal), or otherwise protected species (e.g., raptors, migratory birds)?

2. Is any part of the affected property used for habitat, foraging area, or refuge by any species used as a recreational (e.g., game animals) and/or commercial resource?

3. Is any part of the affected property used for habitat, foraging area, or refuge by any plant or animal species? This includes plants considered "weeds" and opportunistic insect and animal species (such as cockroaches and rats) if they are used as a food source for other species in the area.

III. Exposure Pathways

1. Could receptors be impacted by contaminants via direct contact?
   Is a receptor located in or using an area where it could contact contaminated air, soil[3], or surface water?

For Questions 2 and 3, note that one must answer "yes" to all three bullets in order to be directed to the "exclusion denied" box of the decision tree. This is because answering "no" to one of the questions in the bullet list indicates that a complete exposure pathway is not present. For example, in Question 2, if the chemical cannot leach or dissolve to groundwater (bullet 1), there is no chance of ecological receptors being exposed to the chemical through contact with contaminated groundwater. Similarly, the responses to the questions in Question 4 determine whether a complete pathway exists for exposure to NAPL.

2. Could receptors contact contaminants via groundwater?
   - Can the chemical leach or dissolve to groundwater[4]?
   - Can groundwater mobilize the chemical?
   - Could (does) contaminated groundwater discharge into known or potential receptor habitats?

3. Could receptors contact contaminants via runoff (i.e., surface water and/or suspended sediment) or erosion by water or wind?
   - Are chemicals present in surface soils?
   - Can the chemical be leached from or eroded with surface soils?
   - Is there a receptor habitat located downgradient of the leached/eroded surface soil?

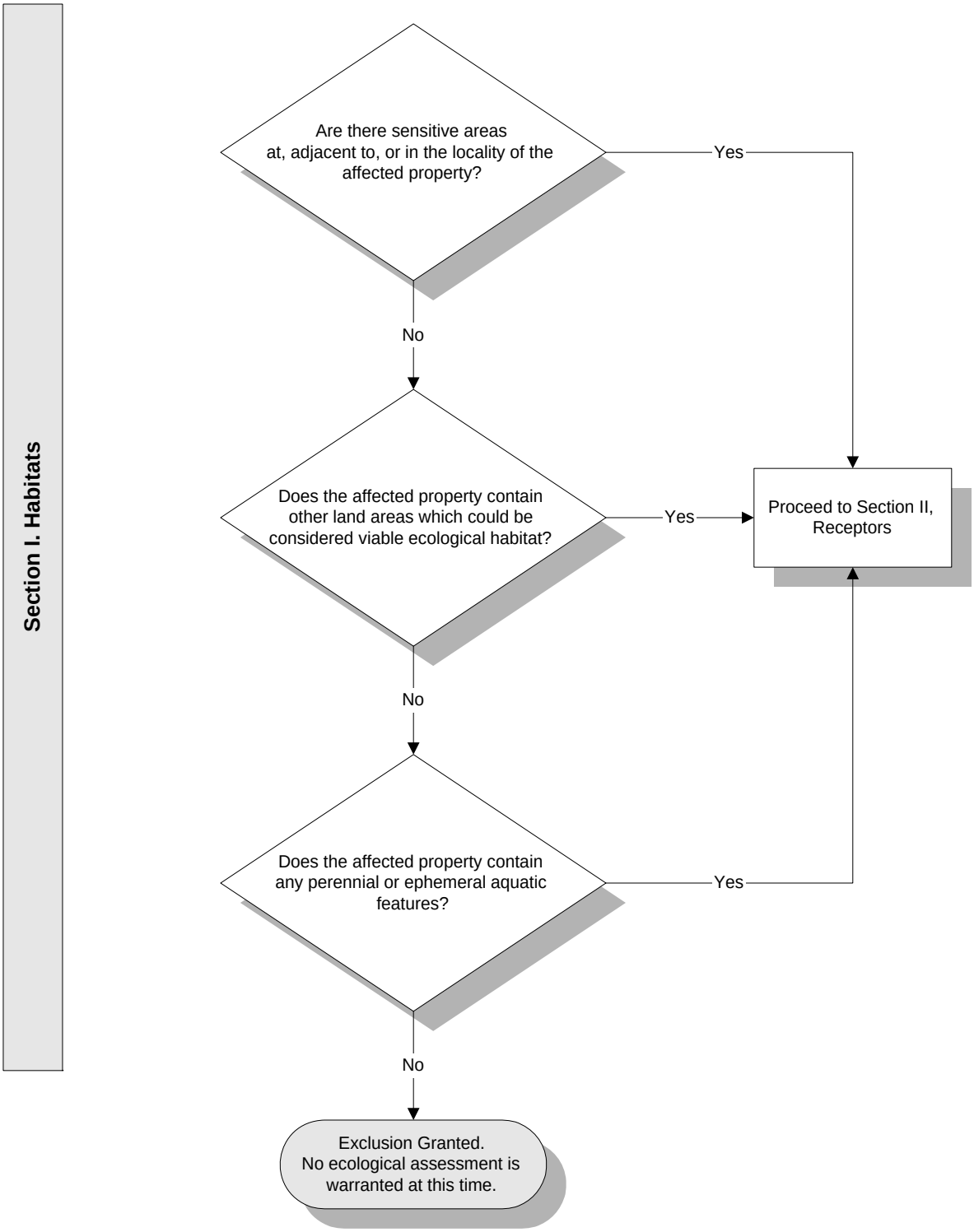
4. Could receptors contact contaminants via migration of non-aqueous phase liquids (NAPL)?
   - Is NAPL present at the site?
   - Is NAPL migrating toward potential receptors or habitats?
   - Could NAPL discharge impact receptors or habitats?

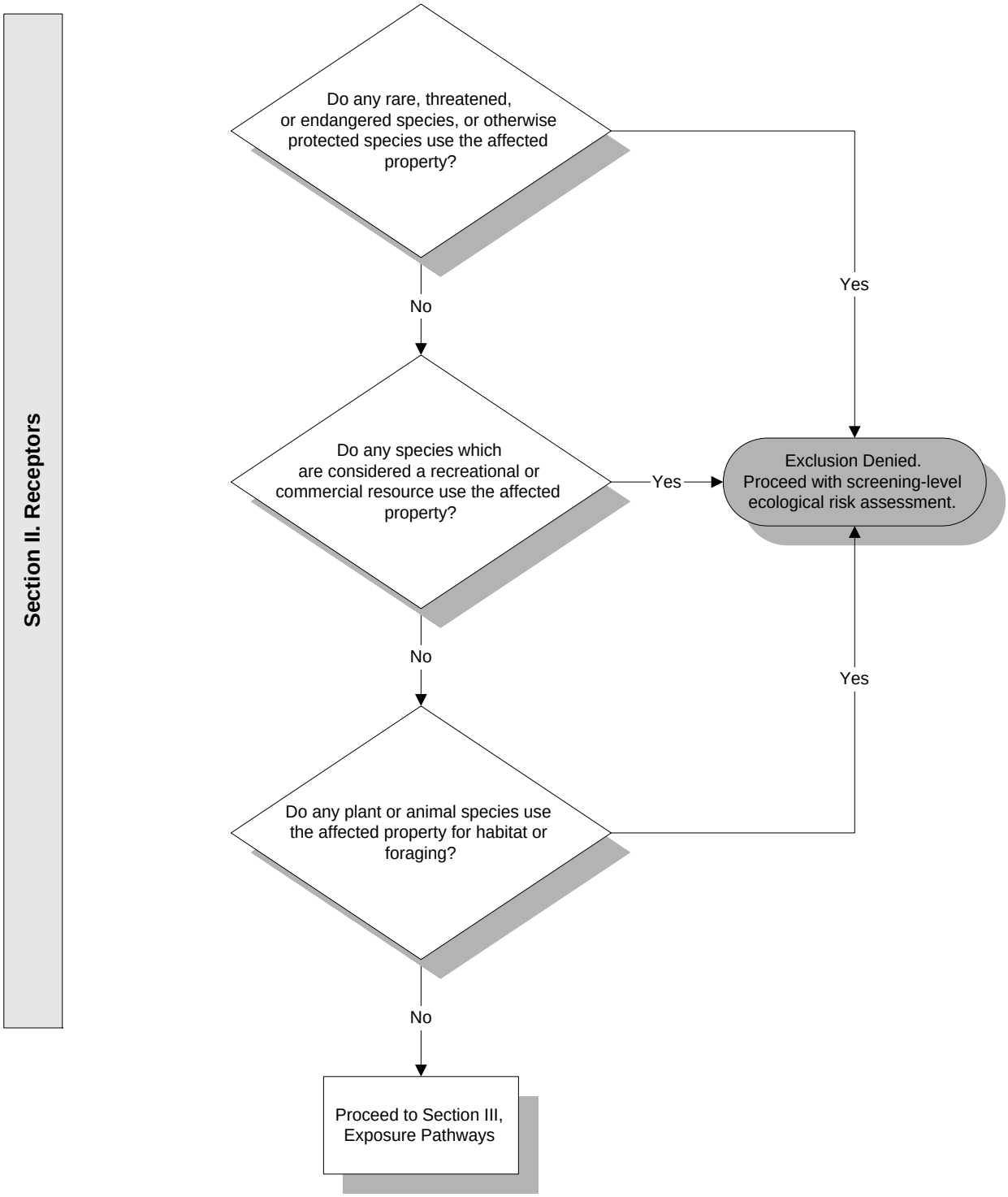
3 For soil, this means contamination less than 5 feet below ground surface (bgs).

4 Information on the environmental fate of specific chemicals can be found on the Internet at *http://www.epa.gov/opptintr/chemfact/* or at a local library in published copies of the *Hazardous Substances Data Bank*.

Figure 1 -Ecological Exclusion Criteria Decision Tree
(Refer to corresponding checklist for the full text of each question)

Figure 1 - Exclusion Criteria Decision Tree (continued)




Section II. Receptors
Do any rare, threatened, or endangered species, or otherwise protected species use the affected property?
Yes
No
Do any species which are considered a recreational or commercial resource use the affected property?
Yes
Exclusion Denied. Proceed with screening-level ecological risk assessment.
No
Yes
Do any plant or animal species use the affected property for habitat or foraging?
No
Proceed to Section III, Exposure Pathways

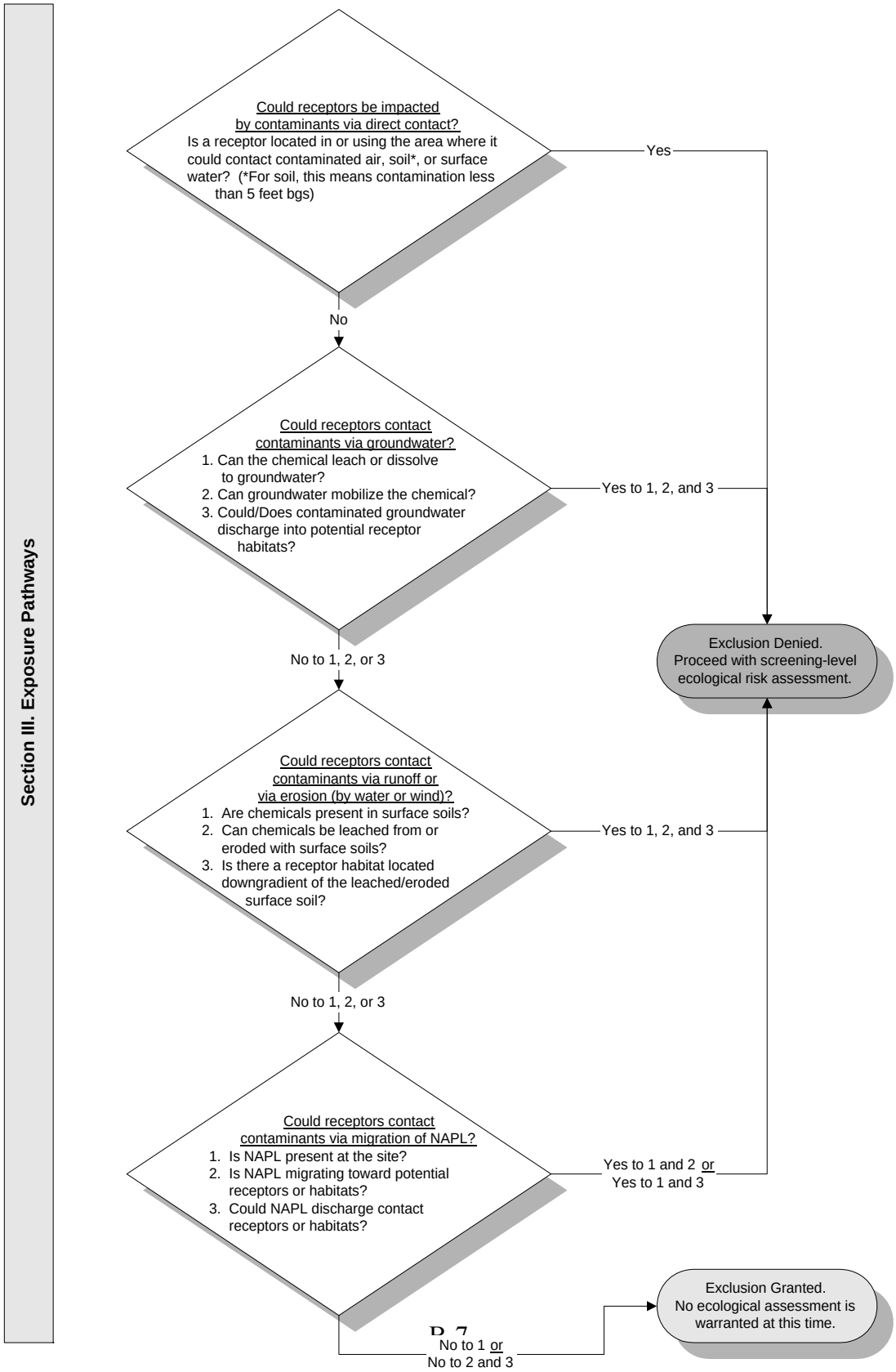



Figure 1 - Exclusion Criteria Decision Tree (continued)