AWMA 2023

RECAP

A few notes for consideration…

Environmental Conditions Review
Limited Site Investigations

- LSI associated with property transactions → ASTM E1903-19
- ASTM E1903-19 Phase II assessments
  - ⇨ Do not meet RECAP investigation requirements
  - ⇨ Not within jurisdiction of LDEQ
  - ⇨ Conducted without LDEQ-RD oversight
  - ⇨ Do not meet requirements for RECAP NFA
- ASTM E1903-19 LSI → LAC 33 Part 1 Subpart 1 Chapter 12 Requests for Review of Environmental Conditions
- "LSI Response" → Environmental Conditions Review (ECR)

Environmental Conditions Review

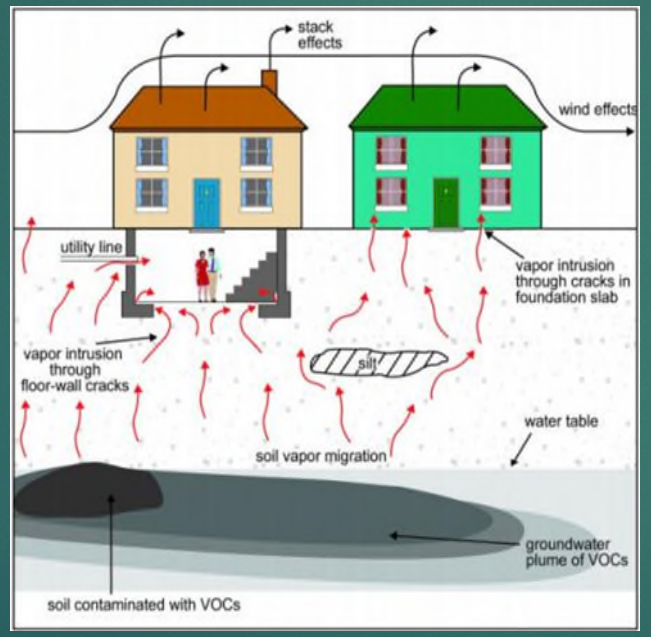
- Applicable only to specific sampling locations and analytes – not the entire property
- Nonindustrial Limiting Screening Standard is applied to individual data points (or the max concentration - not 95%UCL-AM)
- All detected concentrations must be ≤ Nonindustrial Screening Standards
- If detected concentration(s) > Nonindustrial Screening Standards
  - → comply with LDEQ notification requirements
  - → submit RECAP investigation workplan to Remediation Division
- Compliance with nonindustrial RS does NOT imply unrestricted use of the property

LSI: Points for consideration

Concerns and recommendations:

- Sampling locations – not addressing areas most likely to be impacted
  - ✓ Example – former dry cleaner (machine area, drains, likely dumping areas, etc)
  - ✓ RECs identified on Sanborn maps
- Number of sampling locations/depth of sampling locations
- Analyte list – not addressing all potential onsite sources/COC
- Reduced analyte reporting
- If site is likely to require more extensive investigation → collect data in accordance with RECAP requirements

Vapor Intrusion Chlorinated Solvents



EPA https://www.epa.gov/vaporintrusion/what-vapor-intrusion

Vapor Intrusion

RECAP states:

In general, the $Soil_{es}$ and GW_{es} are applicable to soil and groundwater present at a depth **less than or equal to 15 ft bgs** that are impacted with volatile constituents and located beneath an enclosed structure.

The need to evaluate the vapor intrusion pathway for soil and/or groundwater present at a depth **greater than 15 ft bgs** shall be determined by the Department **based on site-specific conditions** (COC present, nature of the release, subsurface characteristics, etc.) and the level of concern associated with the potential migration of volatile emissions from soil and/or groundwater to an enclosed structure.

- VI of chlorinated solvents ≠ VI of petroleum hydrocarbons

- The VI pathway maybe complete for **chlorinated solvents at source depths greater than 15 ft bgs**
  - → PCE, TCE, DCE, VC, EDC, carbon tet, etc

Vapor Intrusion Pathway – Chlorinated Solvents

- EPA-recommended lateral and vertical inclusion zones
  - Initial guideline for identifying buildings that are 'near' a subsurface vapor source and generally warrant assessment
    - Petroleum hydrocarbons 6 to15 feet
    - Chlorinated solvents 100 feet (may increase over time)
    - To determine site-specific inclusion zones - investigate soil vapor migration distance

- Chlorinated Solvents
  - Persistent
  - Move downward through aquifers and clay layers
  - Horizontal and vertical delineation critical to evaluation of VI pathway
  - Breakdown products PCE → TCE → DCE → VC

EPA *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*, June 2015

EPA *Technical Guide For Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites*, June 2015

Vapor Intrusion Pathway – a few notes

- **LDEQ does not regulate indoor**
- LDEQ regulates soil and groundwater contamination (source of vapors)
- Indoor air quality serves as one line of evidence in the evaluation of soil and groundwater contamination
- If vapor intrusion pathway is determined to be complete for an occupied structure → LDEQ consults with LDH for recommendations on appropriate indoor air comparison values
- Soil vapor: The comparison values in ~~FAQ Soil Gas H5 x alpha Table~~ (and the alpha factors) are no longer recommended for evaluation of soil gas/subslab vapor

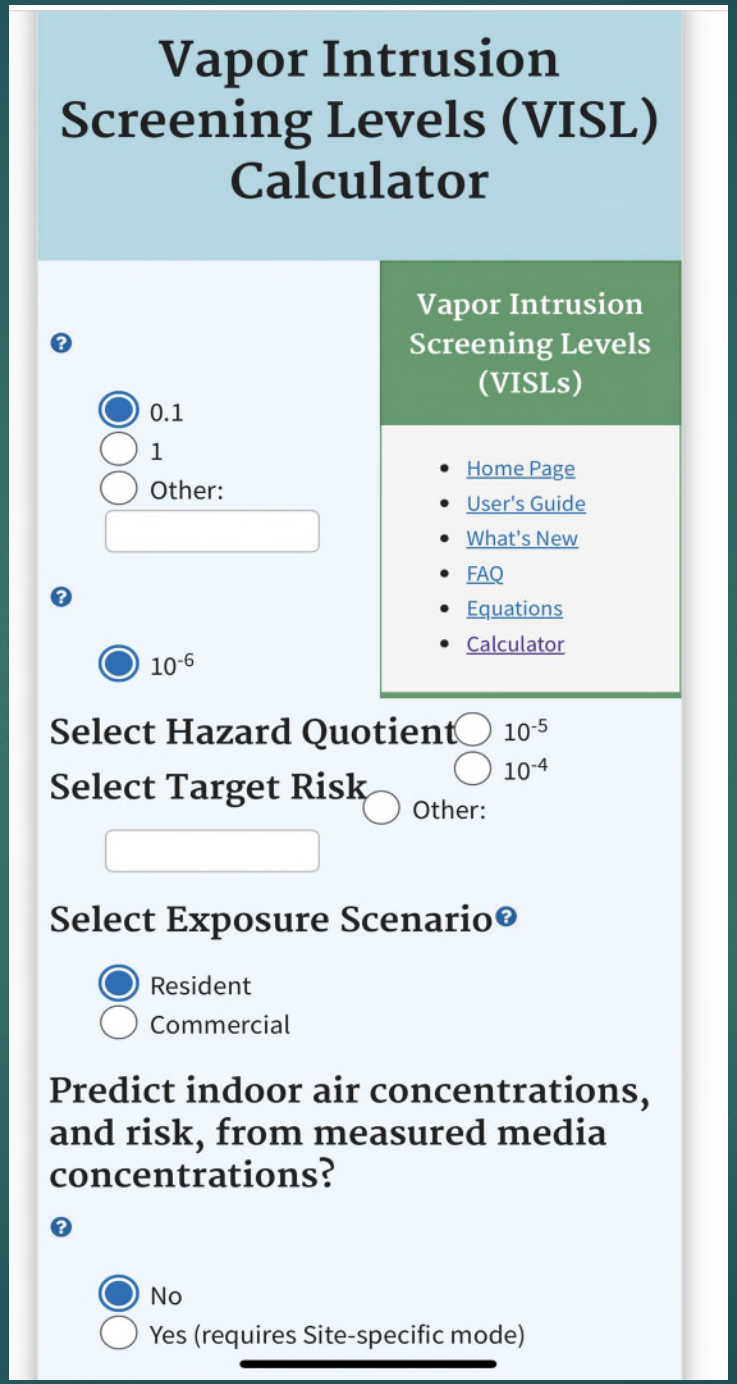
Vapor Intrusion Pathway

- New toxicity values for PCE, TCE, carbon tetrachloride, 1,1,1-TCA, cis-1,2-DCE, and dichloromethane – recommend use of **MO-2 or MO-3** (TCE)
- **TCE is a mutagen**, therefore MO-2 and MO-3 residential standards cannot be calculated using RECAP ~~spreadsheet~~ → **MO-3 EPA VISL**

- EPA Vapor Intrusion Screening Level Calculator (VISL)
  - Provides risk-based screening-level target concentrations for groundwater, near-source soil gas, sub-slab soil vapor, and indoor air
  - Can estimate indoor air concentrations based on site-specific soil vapor or groundwater data
  - For planning purposes; may be an acceptable tool under MO-3 for development of RS based on site-specific conditions
  - https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator

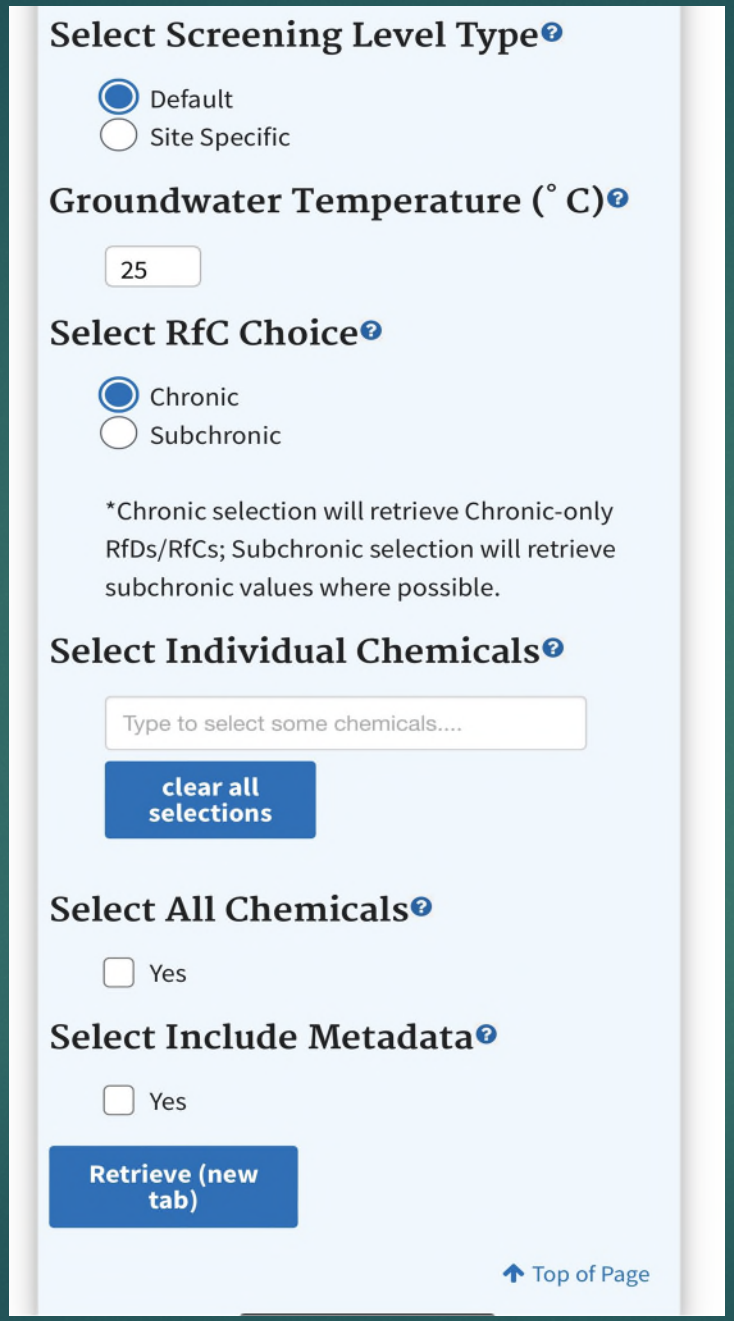
EPA Vapor Intrusion Screening Level Calculator

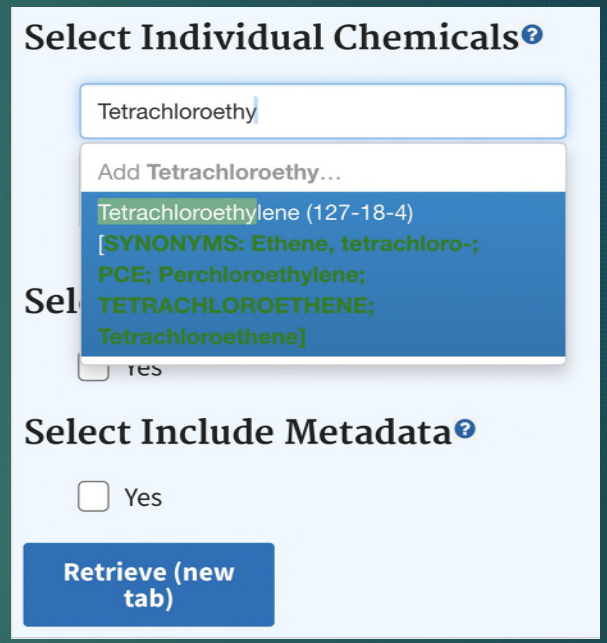
https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator



EPA Vapor Intrusion Screening Level Calculator

https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator





Default VISL Results

1

Variable	Value
Exposure Scenario	Resident
Temperature for Groundwater Vapor Concentration C	25
ED_{res} (exposure duration) years	26
TR (target risk) unitless	1E-06
THQ (target hazard quotient) unitless	0.1
LT (lifetime) years	70
EF_{res} (exposure frequency) days/year	350
ED_{0-2} (mutagenic exposure duration first phase) years	2
ED_{2-6} (mutagenic exposure duration second phase) years	4
ED_{6-16} (mutagenic exposure duration third phase) years	10
ED_{16-26} (mutagenic exposure duration fourth phase) years	10
EF_{0-2} (mutagenic exposure frequency first phase) days/year	350
EF_{2-6} (mutagenic exposure frequency second phase) days/year	350
EF_{6-16} (mutagenic exposure frequency third phase) days/year	350
EF_{16-26} (mutagenic exposure frequency fourth phase) days/year	350
ET_{res} (exposure time) hours/day	24
ET_{0-2} (mutagenic exposure time first phase) hours/day	24
ET_{2-6} (mutagenic exposure time second phase) hours/day	24
ET_{6-16} (mutagenic exposure time third phase) hours/day	24
ET_{16-26} (mutagenic exposure time fourth phase) hours/day	24
AF_{gw} (Attenuation Factor Groundwater) unitless	0.001
AF_{ss} (Attenuation Factor Sub-Slab) unitless	0.03

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EPA Vapor Intrusion Screening Level Calculator
https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator

Resident Vapor Intrusion Screening Levels (VISL)

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; U = user provided; G = see RSL User's Guide Section 5; CA = cancer; NC = noncancer.

Chemical	CAS Number	Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does the chemical have inhalation toxicity data? (IUR and/or RfC)	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Soil Source? ($C_{vp} > C_{i,a}$,Target?)	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Groundwater Source? ($C_{hc} > C_{i,a}$,Target?)	Target Indoor Air Concentration (TCR=1E-06 or THQ=0.1) MIN($C_{ia,c}$,$C_{ia,nc}$) ($\mu g/m^3$)	Toxicity Basis	Target Sub-Slab and Near-source Soil Gas Concentration (TCR=1E-06 or THQ=0.1) C_{sg},Target ($\mu g/m^3$)	Target Groundwater Concentration (TCR=1E-06 or THQ=0.1) C_{gw},Target ($\mu g/L$)
Tetrachloroethylene	127-18-4	Yes	Yes	Yes	Yes	4.17E+00	NC	1.39E+02	5.76E+00

Is Target Groundwater Concentration < MCL? (C_{gw} < MCL?)	Pure Phase Vapor Concentration C_{vp}\ (25 °C)\ ($\mu g/m^3$)	Maximum Groundwater Vapor Concentration C_{hc}\ ($\mu g/m^3$)	Temperature for Maximum Groundwater Vapor Concentration (°C)	Lower Explosive Limit LEL (% by volume)	LEL Ref	IUR $(ug/m^3)^{-1}$	IUR Ref	RfC (mg/m^3)	RfC Ref	Mutagenic Indicator	Carcinogenic VISL TCR=1E-06 $C_{ia,c}$ ($\mu g/m^3$)	Noncarcinogenic VISL THQ=0.1 $C_{ia,nc}$ ($\mu g/m^3$)
No (5)	1.65E+08	1.49E+08	25	-		2.60E-07	I	4.00E-02	I	No	1.08E+01	4.17E+00

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EPA Vapor Intrusion Screening Level Calculator
https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator

Chemical Properties

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Chemical	CAS Number	Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does the chemical have inhalation toxicity data? (IUR and/or RfC)	MW	MW Ref	Vapor Pressure VP (mm Hg)	VP Ref	S (mg/L)	S Ref	MCL (ug/L)
Tetrachloroethylene	127-18-4	Yes	Yes	165.83	PHYSPROP	1.85E+01	PHYSPROP	2.06E+02	PHYSPROP	5

HLC (atm-m ^{3}/mole)	Henry's Law Constant (unitless)	H` and HLC Ref	Henry's Law Constant Used in Calcs (unitless)	Normal Boiling Point BP (K)	BP Ref	Critical Temperature T_c (K)	T_c Ref	Enthalpy of vaporization at the normal boiling point $\Delta H_{v,b}$ (cal/mol)	$\Delta H_{v,b}$ Ref	Lower Explosive Limit LEL (% by volume)	LEL Ref
1.77E-02	7.24E-01	PHYSPROP	7.24E-01	394.45	PHYSPROP	6.20E+02	YAWS	8.29E+03	CRC	-	

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EPA Vapor Intrusion Screening Level Calculator
https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator

Vapor Intrusion Pathway
EPA TCE Indoor Air Recommendations

- TCE – developmental effects during first trimester of pregnancy
- TCE – EPA response action levels for indoor air (residential)
  - EPA Superfund, EPA Regions 3, 7, 9, 10: 2 ug/m^3
  - Compared to time-integrated samples = average concentrations
- TCE – ATSDR health-based guideline for indoor air (residential): 2.1 ug/m^3
- TCE - EPA health guidelines for indoor air (industrial 8-hr)
  - EPA Region 3, 9: 8 ug/m^3
  - EPA Region 7: 6 ug/m^3
  - EPA Region 10: 8.4 ug/m^3

EPA Region 9 Response Action Levels and Recommendations to Address Near-Term Inhalation Exposures to TCE in Air from Subsurface Vapor Intrusion. July 9, 2014
EPA Region 3 Hazardous Site Cleanup Division Technical Support Branch recommendations to Risk Assessors and Risk Managers to address inhalation exposures of trichloroethylene due to vapor intrusion. March 28, 2016

EPA Region 10 OEA Recommendations Regarding Trichloroethylene Toxicity in Human Health Risk Assessments. December 13, 2012

EPA Region 7 Revised Vapor Intrusion Risk Management Decision Matrix. February 24, 2017

Subsurface vapor Intrusion Modeling

- EPA Johnson and Ettinger Model Spreadsheet Tool Version 6.0 (Sept 2017)
- https://www.epa.gov/vaporintrusion/epa-spreadsheet-modeling-subsurface-vapor-intrusion
- Allows site-specific data with regard to:
  - Source characteristics
  - Building characteristics
  - Vadose zone characteristics
  - Exposure parameters

RECAP

Standards

SS and RS for COC not listed in RECAP Tables 1-3

- **All COC are regulated under RECAP**
- Most current toxicity data shall be used
  - ✓ IRIS https://www.epa.gov/iris
  - ✓ PPRTV https://www.epa.gov/pprtv
  - ✓ Others sources: ATSDR MRLs, California EPA, HEAST
  - ✓ No toxicity value? Discuss with LDEQ tox staff

- Toxicity Value Unit conversions for use in spreadsheet:
  - Reference concentration (RfC) mg/m^3 → Inhalation Reference Dose (RfD$_i$) mg/kg/day
    - RfC x 20 m^3/day ÷ 70 kg
  - Inhalation Unit Risk (IUR) risk/ug/m^3 → Inhalation Slope Factor (SF$_i$) risk/mg/kg/day
    - IUR x 70 kg ÷ 20 mg/m3 x 1000 ug/mg

IRIS - Cumene

Noncancer Assessment
Reference Concentration for Inhalation Exposure
RfC (mg/m^3)*

System	RfC (mg/m^3)	Basis	PoD	Composite UF
Endocrine, Urinary	4×10^{-1}	Increased kidney weights in female rats and adrenal weights in male and female rats	NOAEL(HEC): 4.35×10^{2} mg/m^3	1000

Noncancer Assessment
Reference Dose for Oral Exposure
RfD (mg/kg/day)

System	RfD (mg/kg-day)	Basis	PoD	Composite UF
Urinary	1×10^{-1}	Increased average kidney weight in female rats	NOAEL : 1.10×10^{2} mg/kg-day	1000

RfC = 4E-01 mg/m^3 x 20 m^3/day ÷70 kg =
RfDi = 1.14E-01 mg/kg-day

RFDo = 1E-01 mg/kg-d

Noncarcinogenic targets:
Kidney and adrenal

IRIS - Formaldehyde

Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

- **Inhalation Unit Risk: 1.3 x 10^{-5} per µg/m^3**
  - **Extrapolation Method:** Linearized multistage procedure, additional risk
  - **Tumor site(s):** Respiratory
  - **Tumor type(s):** Squamous cell carcinoma (Kerns et al., 1983)

Convert IUR $(ug/m^3)^{-1}$ to Inhalation Slope Factor (SF_i) $(mg/kg\text{-}d)^{-1}$:

1.3E-05/ug/m^3 x 70 kg x 1000 ug/mg ÷ 20 m^3/d = 4.6E-02 mg/kg-d = SF_i

Volatility

- RECAP
  - Molecular weight < 200 g/mole and > HLC 1E-05 atm-m^3/mole
- EPA Regional Screening Level User's Guide
  - > HLC 1E-05 atm-m^3/mole or vapor pressure > 1 mm Hg

RS for COC not listed in RECAP Tables 1-3

- Chemical/physical data
  - Molecular weight, K_{oc}, HLC, D_a, D_w, and water solubility
  - EPA Chemical-specific parameters table
    - ✓ https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

- LDEQ RECAP Spreadsheet vs Spreadsheets from other sources
  - Results not always same as RECAP Spreadsheet
  - Henry's Law Constant: H (atm-m^3/mol) vs H' (dimensionless)
  - H' = H x 41

RS for COC not listed in RECAP Tables 1-3

1. SF&RfD Tab – enter toxicity values

	ADDITIONAL COMPOUNDS										
	ORGANIC COUMPOUNDS	CAS #	SF_o		SF_i		RfD_o		RfD_i		ABS
VOC	Bis(2-chloroisopropyl)ether	108-60-1	7.00E-02	H	3.50E-02	H	4.00E-02	I	4.00E-02	*	0
VOC	Benzene	71-43-2	2.90E-02	I	2.90E-02	I	4.00E-03	I	8.60E-03	I	0
VOC	Benzene	71-43-2	2.90E-02	I	2.90E-02	I	4.00E-03	I	8.60E-03	I	0
VOC	Benzene	71-43-2	2.90E-02	I	2.90E-02	I	4.00E-03	I	8.60E-03	I	0
VOC	Benzene	71-43-2	2.90E-02	I	2.90E-02	I	4.00E-03	I	8.60E-03	I	0
VOC	Benzene	71-43-2	2.90E-02	I	2.90E-02	I	4.00E-03	I	8.60E-03	I	0
SVOC →	Formaldehyde	50-00-0	4.60E-02	*	4.60E-02	I	2.00E-01	I	2.00E-01	*	0.1
	INORGANIC COMPOUNDS										
Metals	Antimony	7440-36-0	*******		*******		4.00E-04	I	4.00E-04	*	0.01
Metals	Antimony	7440-36-0	*******		*******		4.00E-04	I	4.00E-04	*	0.01
Metals	Antimony	7440-36-0	*******		*******		4.00E-04	I	4.00E-04	*	0.01

2. Chem&Phy data Tab – enter physical/chemical properties

ADDITIONAL COMPOUNDS		g/g-mole	cm3/g		atm-m3/mol		cm2/s		cm2/s		mg/L	
ORGANIC COUMPOUNDS	CAS #	MOL. WT	Koc		H		Da		Dw		S	
Bis(2-chloroisopropyl)ether	108-60-1	171.04	6.17E+01	4	1.13E-04	4	5.95E-02	E	6.62E-06	E	1.70E+03	4
Benzene	71-43-2	78.11	6.17E+01	1	5.55E-03	1	8.80E-02	1	9.80E-06	1	1.75E+03	1
Benzene	71-43-2	78.11	6.17E+01	1	5.55E-03	1	8.80E-02	1	9.80E-06	1	1.75E+03	1
Benzene	71-43-2	78.11	6.17E+01	1	5.55E-03	1	8.80E-02	1	9.80E-06	1	1.75E+03	1
Benzene	71-43-2	78.11	6.17E+01	1	5.55E-03	1	8.80E-02	1	9.80E-06	1	1.75E+03	1
Benzene	71-43-2	78.11	6.17E+01	1	5.55E-03	1	8.80E-02	1	9.80E-06	1	1.75E+03	1
Formaldehyde	50-00-0	30.03	3.63E+00	5	3.40E-07	2	1.80E-01	3	2.00E-05	3	5.50E+05	2
INORGANIC COMPOUNDS												
Antimony	7440-36-0	121.75	********	********	********	********	********	********	********	********	********	********
Antimony	7440-36-0	121.75	********	********	********	********	********	********	********	********	********	********
Antimony	7440-36-0	121.75	********	********	********	********	********	********	********	********	********	********

RS for COC not listed in RECAP Tables 1-3

Groundwater Classification 3
GW3NDW and GW3DW Tabs

COMPOUND	LAC 33:IX. 1113(HHNDW) (mg/L)	LAC 33:IX. 1113(HHDW) (mg/L)	MCL (mg/l)	BCF (l/kg)	C (mg/l)	N (mg/l)	LAC(NDW) or max (LAC,MCL, (MIN C, N)) (mg/l)	
ADDITIONAL COMPOUNDS								
ORGANIC COUMPOUNDS								
Bis(2-chloroisopropyl)ether				5.57E+01	8.31E-04	2.33E+00	8.3E-04	(*2)C
Benzene	1.25E-02	1.10E-03	5.00E-03		2.71E-02	3.15E+00	1.3E-02	(*1)LAC(NDW)
Benzene					2.71E-02	3.15E+00	2.7E-02	(*2)C
Benzene					2.71E-02	3.15E+00	2.7E-02	(*2)C
Benzene					2.71E-02	3.15E+00	2.7E-02	(*2)C
Benzene					2.71E-02	3.15E+00	2.7E-02	(*2)C
Formaldehyde				5.40E-01	1.52E-02	1.40E+02	1.5E-02	(*2)C
INORGANIC COMPOUNDS								
Antimony					#VALUE!	3.15E-01	#VALUE!	#VALUE!
Antimony					#VALUE!	3.15E-01	#VALUE!	#VALUE!
Antimony					#VALUE!	3.15E-01	#VALUE!	#VALUE!

GWes, GWair, Soiles: If LAAS is available for COC, it will need to be entered

Calculation of MO-2 RECAP Standards

MO-2: Use of site-specific soil properties

- Values in blue shaded cells can be changed
  - dry soil bulk density
  - total soil porosity
  - water-filled soil porosity
  - air-filled soil porosity,
  - soil particle density
  - fractional organic carbon ex) 0.02 g/g
  - source length and width ex) 295 ft x 295 ft

- Most current toxicity data shall be used
- Geotechnical lab recommended
- **Must be collected in an unimpacted area**

Soil properties & QC Tab

Soil properties		Management Option 2							
Revision Date: 08/04/2003									
Run date:	10/13/2023								
*****calculation inputs*****									
1.7	g/cm3		pb = dry soil bulk density						
0.358491	Lpore/Lsoil		n = total soil porosity						
0.21	Lwater/Lsoil		nw = water-filled soil porosity						
0.148491	Lair/Lsoil		na = air-filled soil porosity						
2.65	g/cm3		ps = soil particle density						
0.02	g/g		foc = fractional organic carbon in soil						
295	(ft) = L = length of the source at the water table								
295	(ft) = W = width of impacted area perpendicular to flow direction of aquifer								
2.0	Acres		AOI site area - input into Q/C equation below						
59.87202	g/m2-s per kg/m3		Q/C = inverse of mean concentration at center of square source						
Q/C Table									
site size	148*148	209*209	295*295	467*467	660*660	1143*1143			
site size	0.5 acre	1 acre	2 acre	5 acre	10 acre	30 acre			
Q/C value	76.3062	67.4304	59.872	51.4648	46.1707	39.2329			

RS for COC not listed in RECAP Tables 1-3

GWes, Gwair, Soiles Tabs
LAAS – C_{ani} and C_{ai}

	Ds	Dcrack	Dcap	Dws	VFgwesni	Cani	Cani	GWesni	GWesni	min value
ORGANIC COUMPOUNDS										
Bis(2-chloroisopropyl)ether	8.69E-04	8.69E-04	3.19E-04	8.45E-04	7.95E-05	1.90E-01	1.46E+02	2.38E+00	1.84E+03	2.4E+00
Benzene	1.20E-03	1.20E-03	1.02E-05	4.07E-04	4.08E-03	2.29E-01	3.14E+01	5.61E-02	7.69E+00	5.6E-02
Benzene	1.20E-03	1.20E-03	1.02E-05	4.07E-04	4.08E-03	2.29E-01	3.14E+01	5.61E-02	7.69E+00	5.6E-02
Benzene	1.20E-03	1.20E-03	1.02E-05	4.07E-04	4.08E-03	2.29E-01	3.14E+01	5.61E-02	7.69E+00	5.6E-02
Benzene	1.20E-03	1.20E-03	1.02E-05	4.07E-04	4.08E-03	2.29E-01	3.14E+01	5.61E-02	7.69E+00	5.6E-02
Benzene	1.20E-03	1.20E-03	1.02E-05	4.07E-04	4.08E-03	2.29E-01	3.14E+01	5.61E-02	7.69E+00	5.6E-02

MO-2: AOI Source Size: Why is it important?

- **Criteria for the Management of Soil and Groundwater Under SO and/or MO-1**
  - The area of impacted soil is approximately 0.5 acre or less. [The Q/C parameter for the calculation of the volatilization factor for $Soil_i$ and $Soil_{ni}$ and the S_w parameter for the calculation of the dilution factors (DF) for $Soil_{GW2}$ and $Soil_{GW3}$ are based on an area of impacted soil that is 0.5 acre in size.]

    Example: Benzene $Soil_i$ (SO or MO-2)

Site size	148*148	209*209	295*295	467*467	660*660	1143*1143
Site size ft^2	21,904	43,681	87,025	218,089	435,600	1,306,449
Site size	0.5 acre	1 acre	2 acre	5 acre	10 acre	30 acre
$Soil_i$ mg/kg	3.1	2.7	2.4	2.1	1.9	1.6

- AOI > 0.5 acre
  - Calculate SO SS using site-specific source area
  - Calculate MO-2 RS using site-specific source area
  - Calculate site-specific dilution factor - Do not use MO-1 default DFs!

Calculation of MO-3 RECAP Standards

MO-3 Site-specific RS

- Most current EPA risk assessment methods preferable
- Most current toxicity data
- Most current default exposure parameters (or site-specific exposure parameters)
- Site-specific or LDEQ state soil properties
- EPA Calculator recommended for $Soil_{ni}$, $Soil_{i}$, GW_{1}, $GW_{2,}$ mutagens
- LDEQ Spreadsheet: GW_{3}, $Soil_{GW3}$
- EPA Vapor Intrusion Screening Level (VISL) calculator for target groundwater, soil gas, subslab vapor, and indoor air comparison values
- Mutagens

Mutagens

Acrylamide, benzidine, Cr^{+6}, chloroprene, 1,2-dibromo-3-chloropropane, ethylene oxide, 3-methylchlolanthrene, methylene chloride, 4,4'-methylene-bis(2-chloroaniline), N-nitroso-N-ethylurea, N-nitroso-N-methylurea, N-nitrosodiethylamine, N-nitrosodimethylamine, cPAH, TCE, 1,2,3-trichloropropane, urethane, vinyl chloride

- Carcinogens that cause a change in the DNA of a cell are referred to as mutagens
- DNA changes may cause certain diseases, such as cancer
- Increased susceptibility to mutagens during early-life
- In the absence of chemical-specific data to evaluate differences in susceptibility, age-dependent adjustment factors (ADAFs) should be applied
- The EPA Guidance establishes ADAFs for three specific age groups
  - 10X risk for birth to <2 yr
  - 3X risk for 2 yr to <16 yr
  - 1X risk for 16-70 yr

→ Nonindustrial RS for mutagens cannot be calculated using LDEQ spreadsheet; calculate under MO-3 using EPA calculator with LDEQ state defaults were available

Mutagens: Example of the application of ADAF for residential soil ingestion IFSM –Resident Mutagenic Soil Ingestion Rate - Age-adjusted

incidental ingestion of soil*

$$SL_{res\text{-}soil\text{-}mu\text{-}ing}\left(\frac{mg}{kg}\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IFSM_{res\text{-}adj}\left(\frac{166{,}833\ mg}{kg}\right) \times \left(\frac{10^{-6}\ kg}{mg}\right)}$$

where:

$$IFSM_{res\text{-}adj}\left(\frac{166{,}833\ mg}{kg}\right) = \left(\begin{array}{l} \frac{EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times ED_{0\text{-}2}\ (2\ years) \times IRS_{0\text{-}2}\left(\frac{200\ mg}{day}\right) \times 10}{BW_{0\text{-}2}\ (15\ kg)} + \\ \frac{EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times ED_{2\text{-}6}\ (4\ years) \times IRS_{2\text{-}6}\left(\frac{200\ mg}{day}\right) \times 3}{BW_{2\text{-}6}\ (15\ kg)} + \\ \frac{EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times ED_{6\text{-}16}\ (10\ years) \times IRS_{6\text{-}16}\left(\frac{100\ mg}{day}\right) \times 3}{BW_{6\text{-}16}\ (80\ kg)} + \\ \frac{EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times ED_{16\text{-}26}\ (10\ years) \times IRS_{16\text{-}26}\left(\frac{100\ mg}{day}\right) \times 1}{BW_{16\text{-}26}\ (80\ kg)} \end{array}\right)$$

Source: EPA Regional Screening Level Calculator
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

Mutagens – Vinyl Chloride

- Chemical-specific data for cancer susceptibility from early-life exposure are available
- Application of ADAF is not required; Calculation of updated RS is NOT NECESSARY

EPA IRIS

Commercial/Industrial

- Oral Slope Factor: 7.2×10^{-1} per mg/kg-day (Continuous lifetime exposure during adulthood)
- Inhalation Unit Risk: 4.4×10^{-6} per µg/m^3 (Continuous lifetime exposure during adulthood)

Non-industrial/Residential

- Oral Slope Factor: 1.4 per mg/kg-day (Continuous lifetime exposure from birth)
- Inhalation Unit Risk: 8.8×10^{-6} per µg/m^3 (Continuous lifetime exposure from birth)

cPAH: Updated Toxicity Values/Mutagens

- Benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluroanthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene
- Nonindustrial RS are lower due to mutagenicity (MO-3 – EPA SL Calculator)
- Industrial RS are higher due to updated toxicity values

Example: benzo(a)pyrene $Soil_i$

- 2003 RECAP: 0.33 mg/kg
- 2017 tox value update: 2.1 mg/kg (MO-2 RECAP Spreadsheet)

Calculating MO-3 Nonindustrial RS

- EPA Regional Screening Level Calculator – Residential Soil ($Soil_{ni}$)
  - https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

- Input state-specific inputs
  - Default city for climatic zone → Houston
  - Dry soil bulk density 1.5 g/cm^3 → 1.7 g/cm^3
  - Water-filled soil porosity 0.15 L_{water}/L_{soil} → 0.21 L_{water}/L_{soil}
  - TR = 10^{-6}; THQ 1 or 0.1

- Site-specific inputs, e.g. source size, geotechnical data (foc), etc

MO-3
Soil$_{ni}$

RSL Calculator

Regional Screening Levels (RSLs)

- Home Page
- User's Guide
- What's New
- Frequent Questions
- Equations
- RSL Calculator
- Generic Tables
- Contact Us

- (●) Regional Screening Levels (RSLs)
- ( ) Regional Removal Management Levels (RMLs)

Select Screening Level Type

Select Hazard Quotient
- ( ) 0.1
- (●) 1
- ( ) Other:

Select Target Risk
- (●) 10^{-6}
- ( ) 10^{-5}
- ( ) 10^{-4}
- ( ) Other:

Select Scenario
- (●) Resident
- ( ) Composite Worker (presented in Generic Tables)
- ( ) Indoor Worker

Select Media:
- [x] Soil
- [ ] Air
- [ ] Tap Water

Select Screening Level Choice
- ( ) Defaults
- (●) Site Specific

Select Chemical Info Type:
- ( ) Database hierarchy defaults
- (●) User-provided

Select Risk Output
- (●) No
- ( ) Yes

Select RfD/RfC Choice
- (●) Chronic
- ( ) Subchronic

EPA Regional Screening Level Calculator
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

Select Chemicals

Tetrachloroethylene (127-18-4) [SYNONYMS: Ethene, tetrachloro-; PCE; Perchloroethylene; TETRACHLOROETHENE; Tetrachloroethene]

clear all selections

Select All Chemicals
- [ ] Yes

Retrieve (new tab)

EPA Regional Screening Level Calculator
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

Particulate Emission Factor Wind Driven

PEF Equation

Houston, TX (6) City (Climatic Zone) - Selection based on most likely climatic conditions for the site

0.5 A_s (acres)

3.49 U_m (mean annual wind speed) m/s

11.32 U_t (equivalent threshold value)

0.5 V (fraction of vegetative cover) unitless

13.6482 A (PEF Dispersion Constant)

18.1754 B (PEF Dispersion Constant)

206.7273 C (PEF Dispersion Constant)

0.0103 F(x) (function dependent on U_m/U_t) unitless

50613383094.59 PEF (particulate emission factor) m^3/kg

76.38526624252 Q/C_{wind} (inverse of the ratio of the geometric m concentration to the emission flux at the center of a square source) g/m^2-s per kg/m^3

NOTES:

1. The Q/C_{wind} equation and the dispersion constants A, B and C were taken from Exhibit D-2 of the Supplemental Soil Screening Guidance
2. A, B, C = PEF region-specific dispersion constants (unitless)

Volatilization Factor and Soil Saturation

C_{sat} Equation

Diffusivity in air (D_{ia}) Equation

Diffusivity in water (D_{iw}) Equation

H` at Temperature other than 25 degrees Celsius

VF Unlimited Reservoir Equation - Method 1

Vapor Pressure at Temperature other than 25 degrees Celsius

0.006 foc (fraction organic carbon in soil) g/g

Houston, TX (6) City (Climatic Zone) - Selection based on most likely climatic conditions for the site

1.7 ρ_b (dry soil bulk density) g/cm^3

2.65 ρ_s (soil particle density) g/cm^3

0.5 A_s (acres)

25 T_w (groundwater temperature) degrees Celsiu

0.21 θ_w (water-filled soil porosity) L_{water}/L_{soil}

950000000 T (exposure interval) s

13.6482 A (VF Dispersion Constant)

18.1754 B (VF Dispersion Constant)

206.7273 C (VF Dispersion Constant)

0.358490566037 n (total soil porosity) L_{pore}/L_{soil}

76.38526624252 Q/C_{vol} (inverse of the ratio of the geometric me concentration to the emission flux at the center of a square source) g/m^2-s per kg/m^3

0.148490566037 θ_a (air-filled soil porosity) L_{air}/L_{soil}

Site-specific Resident Soil Inputs

Variable	Resident Soil Default Value	Site-Specific Value
A (PEF Dispersion Constant)	16.2302	13.6482
A (VF Dispersion Constant)	11.911	13.6482
A (VF Dispersion Constant - mass limit)	11.911	11.911
B (PEF Dispersion Constant)	18.7762	18.1754
B (VF Dispersion Constant)	18.4385	18.1754
B (VF Dispersion Constant - mass limit)	18.4385	18.4385
City (PEF Climate Zone) Selection	Default	Houston, TX (6)
City (VF Climate Zone) Selection	Default	Houston, TX (6)
C (PEF Dispersion Constant)	216.108	206.7273
C (VF Dispersion Constant)	209.7845	206.7273
C (VF Dispersion Constant - mass limit)	209.7845	209.7845
foc (fraction organic carbon in soil) g/g	0.006	0.006
F(x) (function dependent on U $_{mm}$/U$_t$) unitless	0.194	0.0103
n (total soil porosity) L $_{pore}$/L$_{soil}$	0.43396	0.3584905660377
ρ_b (dry soil bulk density) g/cm ^{3}	1.5	1.7
ρ_b (dry soil bulk density - mass limit) g/cm ^{3}	1.5	1.5
PEF (particulate emission factor) m ^{3}/kg	1359344438	50613383094.597
ρ_s (soil particle density) g/cm ^{3}	2.65	2.65
Q/C$_{inh}$ (g/m^2-s per kg/m^3)	93.77	76.385266242524
Q/C$_{inh}$ (g/m^2-s per kg/m^3)	68.18	76.385266242524
Q/C$_{inh}$ (g/m^2-s per kg/m^3 - mass limit)	68.18	68.18
A_s (PEF acres)	0.5	0.5
A_s (VF acres)	0.5	0.5
A_s (VF mass-limit acres)	0.5	0.5
AF$_{0<2}$ (mutagenic skin adherence factor) mg/cm ^{2}	0.2	0.2
AF$_{2<6}$ (mutagenic skin adherence factor) mg/cm ^{2}	0.2	0.2
AF$_{6<16}$ (mutagenic skin adherence factor) mg/cm ^{2}	0.07	0.07
AF$_{16<26}$ (mutagenic skin adherence factor) mg/cm ^{2}	0.07	0.07
AF$_{adult}$ (skin adherence factor - adult) mg/cm ^{2}	0.07	0.07
AF$_{child}$ (skin adherence factor - child) mg/cm ^{2}	0.2	0.2
AT$_{res}$ (averaging time - resident carcinogenic)	365	365

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Default Resident Soil Inputs

Output to XLS

Output to PDF

EPA Regional Screening Level Calculator
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

Site-specific Resident Soil Inputs

Variable	Resident Soil Default Value	Site-Specific Value
BW_{a-2} (mutagenic body weight) kg	15	15
BW_{2-6} (mutagenic body weight) kg	15	15
BW_{6-16} (mutagenic body weight) kg	80	80
BW_{16-26} (mutagenic body weight) kg	80	80
BW_{adult} (body weight - adult) kg	80	80
BW_{child} (body weight - child) kg	15	15
DFS_{adj} (age-adjusted soil dermal factor) mg/kg	103390	103390
$DFSM_{adj}$ (mutagenic age-adjusted soil dermal factor) mg/kg	428260	428260
ED_{total} (exposure duration) years	26	26
ED_{a-2} (mutagenic exposure duration) years	2	2
ED_{2-6} (mutagenic exposure duration) years	4	4
ED_{6-16} (mutagenic exposure duration) years	10	10
ED_{16-26} (mutagenic exposure duration) years	10	10
ED_{adult} (exposure duration - adult) years	20	20
ED_{child} (exposure duration - child) years	6	6
EF_{total} (exposure frequency) days/year	350	350
EF_{a-2} (mutagenic exposure frequency) days/year	350	350
EF_{2-6} (mutagenic exposure frequency) days/year	350	350
EF_{6-16} (mutagenic exposure frequency) days/year	350	350
EF_{16-26} (mutagenic exposure frequency) days/year	350	350
EF_{adult} (exposure frequency - adult) days/year	350	350
EF_{child} (exposure frequency - child) days/year	350	350
ET_{total} (exposure time) hours/day	24	24
ET_{a-2} (mutagenic exposure time) hours/day	24	24
ET_{2-6} (mutagenic exposure time) hours/day	24	24
ET_{6-16} (mutagenic exposure time) hours/day	24	24
ET_{16-26} (mutagenic exposure time) hours/day	24	24
ET_{adult} (adult exposure time) hours/day	24	24
ET_{child} (child exposure time) hours/day	24	24
THQ (target hazard quotient) unitless	0.1	1
$IFS_{res-adj}$ (age-adjusted soil ingestion factor) mg/kg	36750	36750

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EPA Regional Screening Level Calculator
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

Site-specific Resident Soil Inputs

3

Variable	Resident Soil Default Value	Site-Specific Value
IFSM (mutagenic age-adjusted soil ingestion factor) mg/kg	166833.3	166833.3
IRS (mutagenic soil intake rate) mg/day	200	200
IRS (mutagenic soil intake rate) mg/day	200	200
IRS (mutagenic soil intake rate) mg/day	100	100
IRS (mutagenic soil intake rate) mg/day	100	100
IRS (soil intake rate - adult) mg/day	100	100
IRS (soil intake rate - child) mg/day	200	200
LT (lifetime) years	70	70
SA (mutagenic skin surface area) cm ²/day	2373	2373
SA (mutagenic skin surface area) cm ²/day	2373	2373
SA (mutagenic skin surface area) cm ²/day	6032	6032
SA (mutagenic skin surface area) cm ²/day	6032	6032
SA (skin surface area - adult) cm ²/day	6032	6032
SA (skin surface area - child) cm ²/day	2373	2373
TR (target risk) unitless	1.0E-06	1.0E-06
T (groundwater temperature) Celsius	25	25
Theta (air-filled soil porosity) L /L	0.28396	0.1484905660377
Theta (water-filled soil porosity) L /L	0.15	0.21
T (exposure interval) s	819936000	819936000
T (exposure interval) yr	26	26
U (mean annual wind speed) m/s	4.69	3.49
U (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5
VF (volitization factor - mass limit) m ³/kg	.	0

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EPA Regional Screening Level Calculator
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

Site-specific

Resident Risk-Based Regional Screening Levels (RSL) for Soil

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = OW; W = TEF applied; E = RPF applied; G = see user guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF_o (mg/kg-day)$^{-1}$	SF_o Ref	IUR (ug/m^3)$^{-1}$	IUR Ref	RfD (mg/kg-day)	RfD Ref	RfC (mg/m^3)	RfC Ref
Tetrachloroethylene	127-18-4	No	Yes	Organics	2.10E-03	U	2.60E-07	U	6.00E-03	U	4.00E-02	U

GIABS	ABS	RBA	Soil Saturation Concentration (mg/kg)	S (mg/L)	K_{oc}\ (cm^3/g)	K_d\ (cm^3/g)	HLC (atm-m^3/mole)	Henry's Law Constant Used in Calcs (unitless)	H` and HLC Ref	Normal Boiling Point BP (K)	BP Ref	Critical Temperature T_c\ (K)	T_c\ Ref
1	-	1	1.56E+02	2.06E+02	9.49E+01	5.69E-01	1.77E-02	7.24E-01	U	394.15	U	620	U

Chemical Type	D_{ia}\ (cm^2/s)	D_{iw}\ (cm^2/s)	D_A\ (cm^2/s)	Particulate Emission Factor (m^3/kg)	Volatilization Factor Unlimited Reservoir (m^3/kg)	Volatilization Factor Mass Limit (m^3/kg)	Volatilization Factor Selected (m^3/kg)	Ingestion SL TR=1E-06 (mg/kg)	Dermal SL TR=1E-06 (mg/kg)	Inhalation SL TR=1E-06 (mg/kg)
VOC	5.05E-02	9.46E-06	3.84E-04	5.06E+10	5.82E+03	0.00E+00	5.82E+03	3.31E+02	-	6.28E+01

Carcinogenic SL TR=1E-06 (mg/kg)	Ingestion SL Child THQ=1 (mg/kg)	Dermal SL Child THQ=1 (mg/kg)	Inhalation SL Child THQ=1 (mg/kg)	Noncarcinogenic SL Child THI=1 (mg/kg)	Ingestion SL Adult THQ=1 (mg/kg)	Dermal SL Adult THQ=1 (mg/kg)	Inhalation SL Adult THQ=1 (mg/kg)	Noncarcinogenic SL Adult THI=1 (mg/kg)	Screening Level (mg/kg)
5.28E+01	4.69E+02	-	2.43E+02	1.60E+02	5.01E+03	-	2.43E+02	2.31E+02	5.28E+01 ca

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EPA Regional Screening Level Calculator
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

Per and Polyfluoroalkyl Substances - PFAS

- Family of per- and poly-fluorinated organic compounds (3-4000+)
- Many consumer products/many industrial processes contain PFAS
- Limited information available to characterize the presence and potential risks
- EPA analytical methods
  - drinking water
  - non-potable water and other environmental media
  - source air emissions
  - ambient air
  - total organic fluorine –quantify large groups of PFAS in environmental samples (in development)

Per and Polyfluoroalkyl Substances - PFAS

- Physical/Chemical parameters
  - EPA Regional Screening Levels table
  - Risk Assessment Information System (RAIS)
  - ATSDR Tox Profile
  - State sources
  - Others

- Toxicity values
  - EPA IRIS (9 PFAS)
  - EPA PPRTV (3 PFAS)
  - EPA Office of Water (2 PFAS)
  - ATSDR MRLs (9 PFAS)
  - State-derived

Per and Polyfluoroalkyl Substances - PFAS

LDEQ Remediation Division and RECAP

- Due to rapidly evolving science concerning the environmental assessment of PFAS
  - ⇨ No provisional "lookup" RECAP Standards available
  - ⇨ RECAP Standards should be developed by the submitter on a site-specific basis
- Include as analytes for RECAP investigations when known or suspected to be present
- Recommend coordinating with RD prior to investigation and RS calculation

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