



Remedial Action Objectives

Presented by:
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May-June 2019



COMMITMENT & INTEGRITY DRIVE RESULTS



RAOs Agenda

- Determining exposure pathways & cleanup goals
- Considering long-term liability & O&M cost issues
- Lessons learned

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How do you pick what's appropriate?

Establishing Remedial Action Objectives (RAOs) by combining:

- Receptor Scenarios
- Future Use

..and setting RAOs by:

- Meeting Risk-based Standards/Goals and/or
- Protecting/Eliminating Receptor Scenarios

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Risk Assessment & Risk-based Remedial Standards

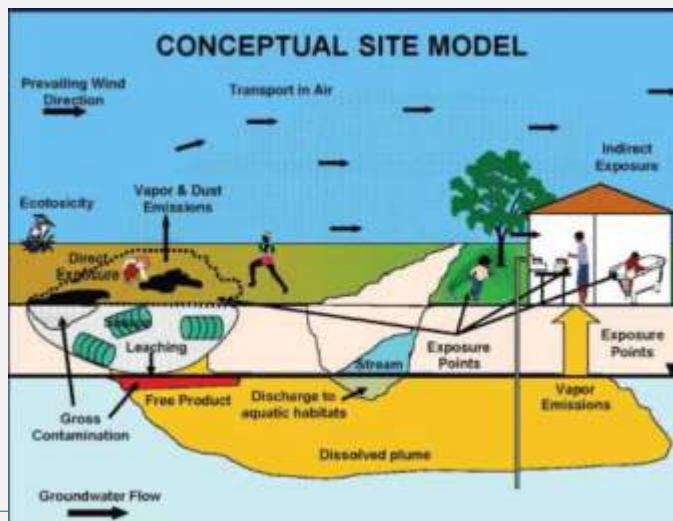
- Receptor Scenario/Risk Assessment Basics
 - Receptor Pathways
 - Ecological RA
 - Human Health RA
- Remedial Standard Frameworks/Examples:
 - EPA Regional Screening Level Tables
 - New York
 - Connecticut



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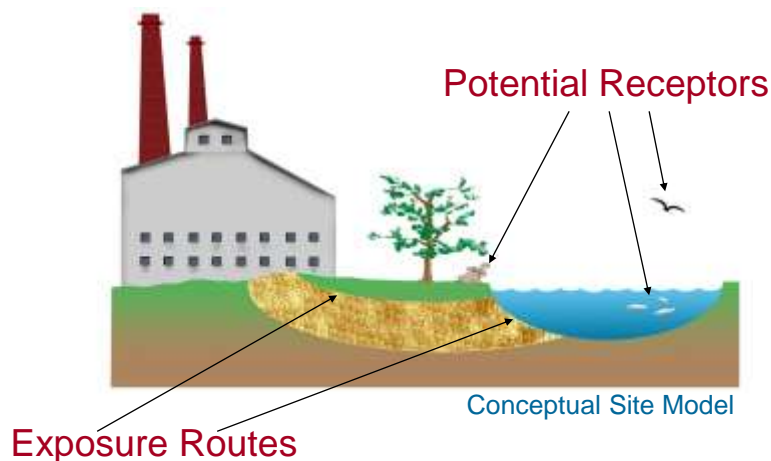
Receptor Pathways



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Ecological Risk Assessment

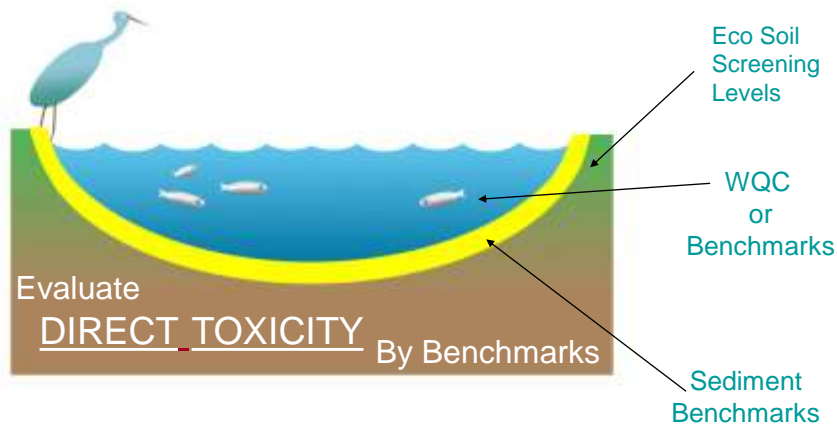
Evaluates effects on plants and animals:



I. SCREENING LEVEL RISK ASSESSMENT

- Uses Conservative Assumptions & Generic Benchmarks from the Literature
- **SINGLE** line of evidence: benchmarks
- Uses soil, sediment or surface water sample data from the RI
- Screens out constituents; remaining ones need more study

SCREENING LEVEL ANALYSIS





II. SITE-SPECIFIC (BASELINE) RISK ASSESSMENT

- Are effects occurring at *my* site
- Uses site data in place of estimated values
- **MULTIPLE** lines of evidence; more expensive
- Much less conservative
- Use if remediation likely or costly

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Human Health Risk Assessment

- Based on Potential Exposure Scenarios
- ...and Calculating Exposures for those Scenarios...

TABLE 7.4

Exposure Scenario Receptors and Pathways

Land Use Category	Unrestricted	Residential	Restricted Residential	Commercial	Industrial
Exposed Population	Adult and Child	Adult and Child	Adult and Child	Adult and Child	Adult and Adolescent
Route of Exposure					
Incidental soil ingestion	✓	✓	✓	✓	✓
Inhalation of soil	✓	✓	✓	✓	✓
Dermal contact with soil	✓	✓	✓	✓	✓
Homegrown vegetable consumption	✓	✓			
Producing animal products for human consumption	✓				
Groundwater protection	✓	✓	✓	✓	✓
Ecological resource protection	✓	✓	✓	✓	✓

Source: Adapted from New York State Department of Environmental Conservation, May 2010, DER-10: Technical Guidance for Site Investigation and Remediation.

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HH Risk Assessment – Exposure Analysis

For instance, the equation used to calculate exposure from inhaling air-borne dust for an adult in an industrial setting is

$$\text{Intake (mg/kg/day)} = (\text{EPC}_{\text{air}} \times \text{IR} \times \text{EF} \times \text{ED}) / (\text{BW} \times \text{AT})$$

where

EPC_{air} = exposure point concentration in air (mg/m³)
 IR = inhalation rate (m³/day)
 EF = exposure frequency (days/year)
 ED = exposure duration (years)
 BW = body weight (kg)
 AT = averaging time (days)

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Toxicity Assessment

- Carcinogens and non-carcinogens
- For carcinogens:

Group A—Carcinogenic to humans
 Group B—"Probably" carcinogenic to humans
 Group C—"Possibly" carcinogenic to humans
 Group D—Not classifiable as to human carcinogenicity
 Group E—Evidence of noncarcinogenicity for humans

In a toxicity assessment, the category of carcinogens includes Groups A and B only. The USEPA's Integrated Risk Information System (IRIS) Web site (www.epa.gov/iris/search_human.htm) lists the chemicals for Groups A, B, and C.

- USEPA's Integrated Risk Information System (IRIS):

www.epa.gov/iris/search_human.htm

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Tiered toxicological sources

The USEPA recommends the following hierarchy of toxicological sources for Superfund Risk Assessments (OSWER Directive 9285.7-53, December 5, 2003):

Tier 1—IRIS.

Tier 2—USEPA's provisional peer reviewed toxicity values (PPRTVs)—

The Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center develops PPRTVs on a chemical-specific basis. These values are available upon request through the project USEPA risk assessor for Superfund projects.

Tier 3—Includes additional USEPA and non-USEPA sources, such as the California EPA toxicity values (www.oehha.ca.gov/risk/ChemicalDB) and the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (www.atsdr.cdc.gov/mrls.html).

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Target Levels...depending on jurisdiction and risk scenario

- Carcinogens ...generally:
 - 10^{-6} for individual carcinogens
 - 10^{-5} for cumulative carcinogens
- Non-carcinogens ...generally:
 - Hazard Index of 0.1 to 1 individual constituents
 - Hazard Index of 1 to 10 cumulative non-carcinogens

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EPA Regional Screening Level Tables

Regional Screening Levels (RSLs)
- Generic Tables
Tables as of: November 2008

<https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>



EPA Regional Screening Level Tables

Regional Screening Levels (RSLs)
- Generic Tables
Tables as of: November 2008

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (see FQ #31); H = HEAST; F = See FAQ; W = see user guide Section 2.3.5; E = see user guide (see user's guide Section 5.10); c = cancer; n = noncancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; SSL values are based on DAF=1; m = Concentration may exceed

Toxicity and Chemical-specific Information											Contaminant							
SFO (mg/kg-day) ¹	k e y	IUR (ug/m ³) ¹	k e y	RfD _c (mg/kg-day)	k e y	RfC (mg/m ³) ¹	k e y	muta gen	GIABS	ABS	C _{REL} (mg/kg)	Analyte	CAS No.					
2.2E-06	I	1.2E-03	O	9.0E-03	I	V	1	1	0.1	1.07E+05	1.14E+05	Acetate	30560-19-1					
				2.0E-02								I	1	0.1	Acetaldehyde	75-07-0		
															Acetochlor	34256-82-1		
				9.0E-01	I	3.1E+01	A	V	1	1	0.1	Acetone	67-64-1					
				2.0E-03		X						1	0.1	Acetone Cyanohydrin	75-86-5			
				6.0E-02		I						V	1	1.28E+05	Acetonitrile	75-05-8		
3.8E+00	C	1.3E-03	C	1.0E-01	I	V	1	1	0.1	2.52E+03	2.27E+04	Acetophenone	98-86-2					
															Acetylaminofluorene, 2-	53-96-3		
				5.0E-04								I	2.0E-05	I	V	1	1	Acrolein
5.0E-01	I	1.0E-04	I	2.0E-03	I	6.0E-03	I	M	1	0.1	1.09E+05	Acrylamide	79-06-1					
				5.0E-01		I						1.0E-03	I	V	1	1.09E+05	Acrylic Acid	79-10-7
				4.0E-02		A						2.0E-03	I	V	1	1.13E+04	Acrylonitrile	107-13-1

<https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>





EPA Regional Screening Level Tables

Regional Screening Levels (RSLs)
- Generic Tables
Tables as of: November 2008

Screening Levels										Protection of Ground Water SSLs			
Resident Soil (mg/kg)	key	Industrial Soil (mg/kg)	key	Resident Air (ug/m ³)	key	Industrial Air (ug/m ³)	key	Tapwater (ug/L)	key	MCL (ug/L)	Risk-based SSL (mg/kg)	key	MCL-based SSL (mg/kg)
7.6E+01	n	9.8E+02	n	1.3E+00	c**	5.6E+00	c**	2.4E+01	n		5.3E-03	n	
1.1E+01	c**	4.9E+01	c**					2.6E+00	c**		5.2E-04	c**	
1.3E+03	n	1.6E+04	n					3.5E+02	n		2.8E-01	n	
6.1E+04	n	6.7E+05	nms	3.2E+04	n	1.4E+05	n	1.4E+04	n		2.9E+00	n	
2.8E+06	nm	1.2E+07	nm	2.1E+00	n	8.8E+00	n						
8.1E+02	n	3.4E+03	n	6.3E+01	n	2.6E+02	n	1.3E+02	n		2.6E-02	n	
7.8E+03	ns	1.2E+05	nms					1.9E+03	n		5.8E-01	n	
1.4E-01	c	6.0E-01	c	2.2E-03	c	9.4E-03	c	1.6E-02	c		7.2E-05	c	
1.4E-01	n	6.0E-01	n	2.1E-02	n	8.8E-02	n	4.2E-02	n		8.4E-06	n	
2.4E-01	c	4.6E+00	c	1.0E-02	c	1.2E-01	c	5.0E-02	c		1.1E-05	c	
9.9E+01	n	4.2E+02	n	1.0E+00	n	4.4E+00	n	2.1E+00	n		4.2E-04	n	
2.5E-01	c*	1.1E+00	c*	4.1E-02	c*	1.8E-01	c*	5.2E-02	c*		1.1E-05	c*	
8.5E+06	nm	3.6E+07	nm	6.3E+00	n	2.6E+01	n						
9.7E+00	c*	4.1E+01	c					1.1E+00	c	2	8.7E-04	c	1.6E-03
6.3E+01	n	8.2E+02	n					2.0E+01	n	3	4.9E-03	n	7.5E-04
6.3E+01	n	8.2E+02	n					2.0E+01	n	2	4.4E-03	n	4.4E-04
3.9E-02	c*	1.8E-01	c	5.7E-04	c	2.5E-03	c	9.2E-04	c	4	1.5E-04	c	8.8E-04

<https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>

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New York State

- NYSDEC Soil Standards
 - Unrestricted
 - Restricted
 - Protection of Eco Resources
 - Protection of Groundwater
- NYSDEC Water Quality Standards
 - Surface Water
 - Groundwater
- NYSDOH Guidance for Evaluating Soil Vapor Intrusion

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NYSDEC Soil Standards

Part 375 – Brownfield Soil Cleanup Criteria

https://www.dec.ny.gov/docs/remediation_hudson_pdf/part375.pdf

The screenshot shows the NYSDEC website header with the New York State logo and navigation links: Services, News, Government, Local. Below the header is the Department of Environmental Conservation logo and additional links: Recreation, Nature, Prevent & Control Pollution. The main content area displays the title "Brownfield and Superfund Regulation" and "6 NYCRR Part 375 - Environmental Remediation Programs", with a note "Effective December 14, 2006".



NYSDEC Soil Standards

Table 375-6.8(a): Unrestricted Use Soil Cleanup Objectives

Contaminant	CAS Number	Unrestricted Use
Metals		
Arsenic	7440-38-2	13 ^a
Barium	7440-39-3	350 ^a
Beryllium	7440-41-7	7.2

Table 375-6.8(b): Restricted Use Soil Cleanup Objectives

Contaminant	CAS Number	Protection of Public Health				Protection of Ecological Resources	Protection of Ground-water
		Residential	Restricted-Residential	Commercial	Industrial		
Metals							
Arsenic	7440-38-2	16 ^f	16 ^f	16 ^f	16 ^f	13 ^f	16 ^f
Barium	7440-39-3	350 ^f	400	400	10,000 ^g	433	820
Beryllium	7440-41-7	14	72	590	2,700	10	47
Cadmium	7440-43-9	2.5 ^f	4.3	9.3	60	4	7.5
Chromium, hexavalent ^h	18540-29-9	22	110	400	800	1 ^h	19
Chromium, trivalent ^h	10095-83-1	36	180	1,500	6,800	41	NS

**Restricted Use requires
Deed Restriction**





NYSDEC Water Quality Standards

Technical & Operational Guidance Series 1.1.1.

<https://www.dec.ny.gov/chemical/23853.html>



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NYSDEC Water Quality Standards

SUBSTANCE (CAS No.)	WATER CLASSES	STANDARD (µg/L)	GUIDANCE VALUE (µg/L)	TYPE	BASIS CODE
Acenaphthene (83-32-6)	A, A-S, AA, AA-S, B, C		5.3	A(C)	
	A, A-S, AA, AA-S, B, C, D		48	A(A)	
	SA, SB, SC, I		6.8	A(C)	
	SA, SB, SC, I, SD		60	A(A)	
	A, A-S, AA, AA-S	20		E	U
Acetone (67-64-7)	A, A-S, AA, AA-S		25	E	U
	GA		50	H(WB)	Z
Tetraphenylmethane (79-07-8)	A, A-S, AA, AA-S	5		H(WB)	J
	GA			H(WB)	J
	A, A-S, AA, AA-S, B, C, D	40		H(PC)	A
	SA, SB, SC, I, SD	40		H(PC)	A

Remarks: * The principal organic contaminant standard for groundwater of 5 µg/L (described elsewhere in this Table) applies to this substance.

BASIS CODE	BASIS
A	Carcinogenic, Human Health
B	Non-carcinogenic, Human Health
F	Former Groundwater Regulations, 6 NYCRR 703.5(a)(3), Human Health or Aesthetics
G	Specific MCL, Human Health or Aesthetics
H	Former Use of or Reference to 10 NYCRR Part 170, Human Health or Aesthetics
I	Principal Organic Contaminant Classes, Human Health
J	Former Groundwater Reference to 10 NYCRR Subpart 5-1 General Standards, Human Health
U	Potable Water, Aesthetics
V	Aquatic Life, Aesthetics
Z	General Organic Guidance Value, Human Health

Division of Water Technical and Operational Guidance Series (1.1.1)
 AMBIENT WATER QUALITY STANDARDS AND GUIDANCE VALUES AND GROUNDWATER EFFLUENT LIMITATIONS
https://www.dec.ny.gov/docs/water_pdf/togs111.pdf

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NYSDOH Guidance for Evaluating Soil Vapor Intrusion

https://www.health.ny.gov/environmental/investigations/soil_gas/svi_guidance/

NEW YORK STATE

Services News Government Local

Department of Health Individuals/Families Providers/Professionals H

You are Here: [Home Page](#) > [Soil Vapor Intrusion](#) > [Guidance for Evaluating Soil Vapor Intrusion in the State of New York](#)

Guidance for Evaluating Soil Vapor Intrusion in the State of New York

This document provides guidance on identifying and addressing existing and potential human exposures to contaminated subsurface vapors associated with petroleum hydrocarbon and volatile organic compound (VOC) intrusion investigation is warranted in the State of New York.

Final Soil Vapor Intrusion Guidance (October 2006)

- [Guidance for Evaluating Soil Vapor Intrusion in the State of New York](#) (Document including appendices (241pp., 21MB, PDF))

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NYSDOH Vapor Intrusion Matrices

https://health.ny.gov/environmental/indoor/vapor_intrusion/update.htm

Soil Vapor/Indoor Air Matrix	Volatile Chemical
Matrix A	carbon tetrachloride 1,1-dichloroethene cis-1,2-dichloroethene trichloroethene
Matrix B	ethylene dibromide tetrachloroethene 1,1,1-trichloroethene
Matrix C	vinyl chloride

Soil Vapor/Indoor Air Matrix A May 2017

Analytes Assigned:
Trichloroethene (TCE), cis-1,2-Dichloroethene (cis-1,2-DCE), 1,1-Dichloroethene (1,1-DCE), Carbon Tetrachloride

SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m ³)	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m ³)		
	< 0.2	0.2 to < 1	1 and above
< 6	1. No further action	2. No Further Action	3. IDENTIFY SOURCE(S) and RESAMPLE or MITIGATE
6 to < 60	4. No further action	5. MONITOR	6. MITIGATE
60 and above	7. MITIGATE	8. MITIGATE	9. MITIGATE

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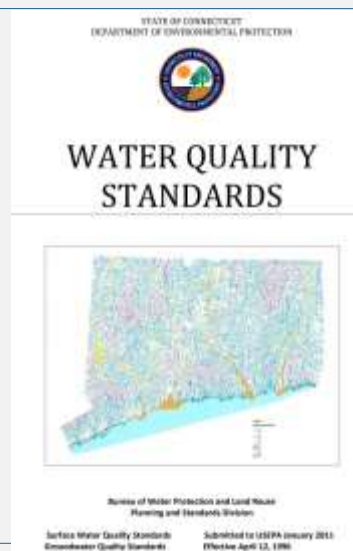
Connecticut

- Water Quality Standards
 - Surface Water
- Remediation Standard Regulations (RSRs)
 - Soil
 - Direct Exposure
 - Protection of Groundwater
 - Groundwater
 - Groundwater Protection
 - Surface Water Protection
 - Soil Vapor/VI pathway
 - Groundwater Volatilization
 - Soil Vapor



CTDEEP Water Quality Standards (WQS)

- CT Water Quality Standards (WQS) for surface water quality criteria
- Groundwater remediation standards in the RSRs...
- ...but RSRs for Surface Water Protection point back to WQS





CTDEEP Water Quality Criteria

APPENDIX D
NUMERICAL WATER QUALITY CRITERIA FOR CHEMICAL CONSTITUENTS

Numerical Water Quality Criteria for Chemical Constituents (µg/L) ¹								
		Aquatic Life Criteria ^{2,3,4}				Human health Criteria		
Chemical Constituents	CASRN	Freshwater: Class AA, A & B		Saltwater: Class SA & SB		Class B, SA & SB Waters Consumption of Fish	Class AA & A Waters Consumption of Water & Fish	Health Designation ⁵
		Acute ⁶	Chronic ⁶	Acute ⁶	Chronic ⁶			
Inorganics ⁷								
Antimony	7440368					600	5.6	TT
Arsenic (total)	7440382	340	150	69	30	0.021	0.011	A
Beryllium	7440417					0.31	0.0077	TT
Cadmium	7440439	1.0	0.125	40	8.8	10,769	5	TT
Chromium (hex)	18540299	16	11	1,100	50	2,019	100	TT
Chromium (tri)	16065931	325	42			1,009,615	100	TT
Copper	7440508	14.3 ⁸	4.8 ⁸	4.3	3.1		1,300	TT

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The Remediation Standard Regulations ("RSRs")

- ◆ Sections 22a-133k-1 through -3 of the Regulations of Connecticut State Agencies ("RCSA")
- ◆ Section 22a-133q-1 RCSA (ELURs)
- ◆ First Promulgated Jan. 1, 1996
- Update/Revisions Effective June 27, 2013

CT's Deed Restriction
enforceable by CTDEEP

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Soil Criteria

Polluted soil at a release area shall be remediated to a concentration that meets either:

- ◆ **Direct Exposure Criteria**
 - ◆ dependent on land use
- &
- ◆ **Pollutant Mobility Criteria**
 - ◆ dependent on groundwater classification
- OR
- ◆ **Background**
 - ◆ concentration that naturally occurs in soil
 - ◆ dependent on local (not regional) sampling data

22a-133k-2(a)(1)

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Direct Exposure Criteria

- | | |
|--|--|
| <ul style="list-style-type: none"> ◆ Residential ◆ Applies to Residential <i>and</i> I/C property (if I/C - property can choose I/C option instead) | <ul style="list-style-type: none"> ◆ Industrial/Commercial (I/C) ◆ Option (alternative to Residential criteria) if site will not be used for residential purposes <i>and ELUR recorded by owner</i> ◆ should consider zoning |
|--|--|

Both Criteria listed in Appendix A

22a-133k-2(b)(1)&(2)

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Direct Exposure Criteria Inaccessible Soil - ELUR

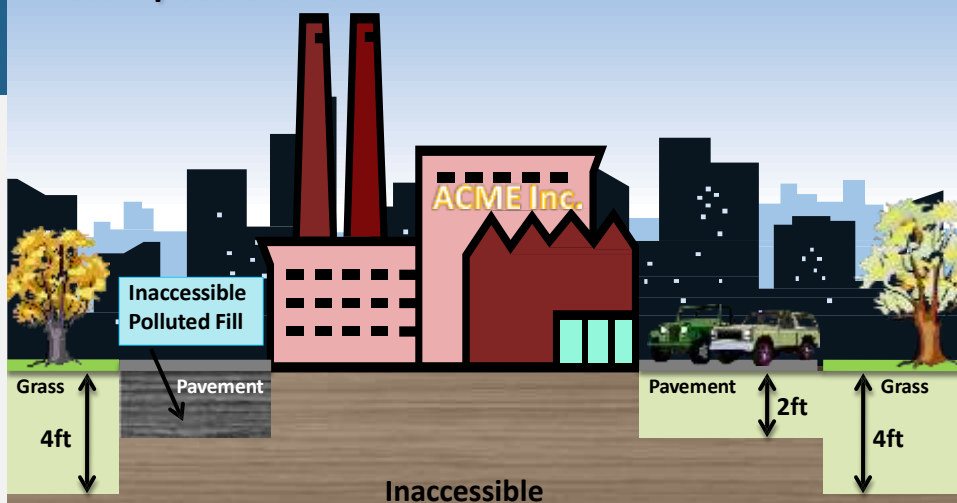
- ◆ An Environmental Land Use Restriction (“ELUR”) must be recorded for Inaccessible Soil before remediation is considered complete - Only the landowner can record an ELUR
- ◆ ELUR must require that inaccessible soil will not be excavated or disturbed and any overlying building will not be demolished unless ELUR is released

22a-133k-2(b)(3)

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Direct Exposure Criteria



Not to Scale

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Pollutant Mobility Criteria

Purpose

- ◆ GA - to prevent *any* pollution of the groundwater
- ◆ GB - to prevent unacceptable *further degradation* of the groundwater



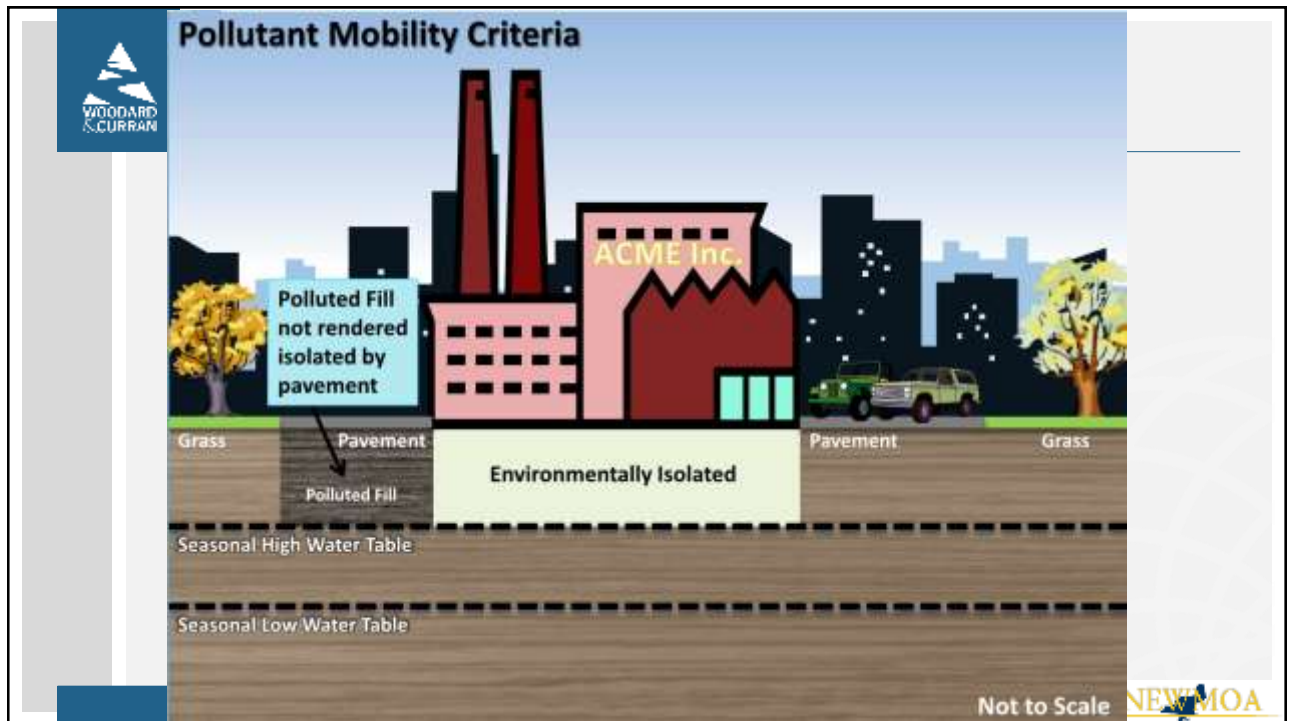
Pollutant Mobility Criteria

Exemption for *Environmentally Isolated Soil*

- ◆ Beneath existing building or other structure approved by the Commissioner
 Note - Building includes roof, walls, floor, etc.
 Other structure examples - bridge abutment, large AST, clarifier, etc. ...or an Engineered Control (e.g. impervious cap)
- ◆ Other conditions on next slide:

22a-133k-1(a)(18) and 22a-133k-2(c)(4)(A) labeled as an "Exception"





SUMMARY OF NUMERICAL CRITERIA

Remediation Standard Regulations

Appendices A, B, C, D, E, and F

JUNE 27, 2013

Media	Soil				Groundwater	
	R-DEC (mg/kg)	I/C-DEC (mg/kg)	GA-PMC (mg/kg)	GB-PMC (mg/kg)	GWPC (µg/L)	
VOLATILE ORGANIC SUBSTANCES						
Acetone	500	1000	14	140	700	
Acrylonitrile	1.1	11	0.01	0.1	0.5	
Benzene	21	200	0.02	0.2	1	
Bromoform	78	720	0.08	0.8	4	
2-Butanone (MEK)	500	1000	8	80	400	
Carbon tetrachloride	4.7	44	0.1	1	5	
Chlorobenzene	500	1000	2	20	100	
Chloroform	100	940	0.12	1.2	6	
Dibromochloromethane	7.3	68	0.01	0.1	0.5	
1,2-Dichlorobenzene (2 DCB)	500	1000	3.1	3.1	600	



Major Components

- ◆ Groundwater Protection Criteria (GWPC)
- ◆ Surface water Protection Criteria (SWPC)
- ◆ Volatilization Criteria (VolC)
- ◆ Background
- ◆ Applying the appropriate criteria
- ◆ Groundwater monitoring
- ◆ Technical Impracticability (TI)

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Groundwater Remediation Standards *Important Concepts*

Regulated by groundwater plume
GA versus GB:

- GB + GC
- GA Impaired
- GA + GAA

Approximately 95 % of
state classified as GA,
GAA or GA Impaired





Development of GWPC

- GWPC generally apply only in GA/GAA Areas
- Risk based number protects people drinking groundwater (10^{-6} carcinogens; HI = 1)
- Basis – Federal MCL, State Action Level or risk-based
- calculated using RSR formula
- Adjusted upward based on detection limit
- Adjusted downward based on ceiling level

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Surface Water Protection Criteria



- ◆ SWPC Located in Appendix D in RSRs
- ◆ Groundwater **plume** which discharges to a surface water body must be remediated to surface water protection criteria

22a-133k-3(b)

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General Volatilization Criteria Requirements

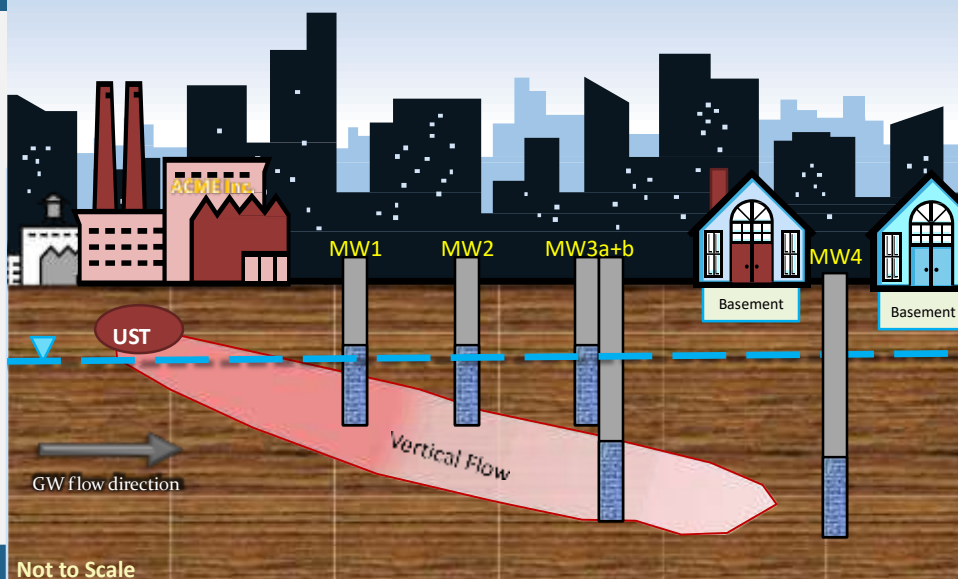
- ◆ Groundwater within **15 feet** of the ground surface (or within 15 feet beneath the lowest level of a building) shall be remediated to the residential volatilization criteria. Proposed 30 ft....
- ◆ Can use I/C Criteria with ELUR
- ◆ Soil Vapor Criteria Also in RSRs (Residential and I/C)

22a-133k-3(c)(1)

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Risk from vapor intrusion only pertains when groundwater is polluted with VOCs at the water table – Standard wells (with representative screens bisecting the water table) are required to demonstrate compliance



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SUMMARY OF NUMERICAL CRITERIA
Remediation Standard Regulations
Appendices A, B, C, D, E, and F
JUNE 27, 2013

Media	Soil				Groundwater/Surface Water				Soil Vapor	
	R-DEC (mg/kg)	I/C-DEC (mg/kg)	GA-PMC (mg/kg)	GB-PMC (mg/kg)	GWPC (µg/L)	SWPC (µg/L)	R-GWVC (µg/L)	I/C-GWVC (µg/L)	R-SVVC (ppmv)	I/C-SVVC (ppmv)
VOLATILE ORGANIC SUBSTANCES									NOTE (2)	NOTE (2)
Acetone	500	1000	14	140	700	NE	50000	50000	2400	8250
Acrylonitrile	1.1	11	0.01	0.1	0.5	20	NE	NE	NE	NE
Benzene	21	200	0.02	0.2	1	710	215	530	1	113
Bromoform	78	720	0.08	0.8	4	10800	920	3800	1.5	6
2-Butanone (MEK)	500	1000	8	80	400	NE	50000	50000	2400	8285
Carbon tetrachloride	4.7	44	0.1	1	5	132	16	40	1	2.7
Chlorobenzene	500	1000	2	20	100	420000	1800	6150	31	106
Chloroform	100	940	0.12	1.2	6	14100	287	710	4.5	10.4
Dibromochloromethane	7.3	68	0.01	0.1	0.5	1020	NE	NE	NE	NE
1,2-Dichlorobenzene (2 DCB)	500	1000	3.1	3.1	600	170000	30500	50000	240	818
1,3-Dichlorobenzene (3 DCB)	500	1000	12	120	600	26000	24200	50000	240	818
1,4-Dichlorobenzene (4 DCB)	28	240	1.5	15	75	26000	50000	50000	950	3270
1,1-Dichloroethane (11DCA)	500	1000	1.4	14	70	NE	34600	50000	850	3037
1,2-Dichloroethane (12DCA)	6.7	63	0.02	0.2	1	2970	21	90	1	1
1,1-Dichloroethylene (11DCE)	1	9.5	0.14	1.4	7	96	1	6	1	1
cis-1,2-Dichloroethylene	500	1000	1.4	14	70	NE	NE	NE	NE	NE
trans-1,2-Dichloroethylene	500	1000	2	20	100	NE	NE	NE	NE	NE
1,2-Dichloropropane	9	84	0.1	1	5	NE	14	60	1	1
1,3-Dichloropropane	3.4	32	0.01	0.1	0.5	34000	6	25	1	1
Ethylbenzene	500	1000	10.1	10.1	700	580000	50000	50000	1650	5672
Ethylene dibromide (EDB)	0.007	0.067	0.01	0.1	0.05	NE	4	16	1	1
Methyl-tert-butyl-ether (MTBE)	500	1000	2	20	100	NE	50000	50000	1000	3415
Methyl isobutyl ketone (MIBK)	500	1000	7	14	350	NE	50000	50000	140	480
Methylene chloride	82	760	0.1	1	5	48000	50000	50000	1200	2807
Styrene	500	1000	2	20	100	NE	580	2065	8	28
1,1,1,2-Tetrachloroethane	24	220	0.02	0.2	1	NE	12	50	1	1.5
1,1,2,2-Tetrachloroethane	3.1	29	0.01	0.1	0.5	110	23	100	1	1
Tetrachloroethylene (PCE)	12	110	0.1	1	5	88	1500	3820	11	27
Toluene	500	1000	20	67	1000	4000000	23500	50000	760	2815
1,1,1-Trichloroethane (TCA)	500	1000	4	40	200	62000	20400	50000	1310	4520
1,1,2-Trichloroethane	11	100	0.1	1	5	1260	8000	19600	40	93

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How do you pick what's appropriate?

Establishing Remedial Action Objectives (RAOs) by combining:

- Receptor Scenarios
- Future Use

..and setting RAOs by:

- Meeting Risk-based Standards/Goals and/or
- Protecting/Eliminating Receptor Scenarios

...and considering Long-term liability & O&M(&M) cost issues...

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Long-term liability & O&M(&M) cost issues

- “Passive”
 - Institutional Controls (e.g. zoning, deed restrictions)
 - Engineered Controls w/o maintenance (e.g. buildings, liners/passive venting, reactive permeable barriers)
 - May still have monitoring/inspection costs going forward!
- “Active”
 - Engineered Controls w/maintenance (e.g. caps, access limitations)
 - O&M&M of long-term systems (e.g. pump & treat, AS/SVE, SSDS, ...)
 - MNA/Long-term monitoring costs



Lessons Learned

- Ensure up front that future use is acceptable
- Having specific future site configuration and integrating remedial goals/approach can save a lot of time & \$\$
- Start Institutional Controls process early in parallel with RAO and remedial technology selection





Questions/Discussion

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