

## Public Discussion Document

### Remediation Standard Regulation (RSR) Fate and Transport Interim Update for Volatilization Criteria May 6, 2016

(Accepting Comments through June 3, 2016: [DEEP.cleanup.transform@ct.gov](mailto:DEEP.cleanup.transform@ct.gov))

The Department of Energy and Environmental Protection (DEEP) is developing “draft discussion documents” of ideas for potential future amendment to DEEP regulations, or new provisions for regulations, to address remediation of releases and sites where hazardous substances and/or oil have been released. As a draft discussion document, the language is not structured to read exactly as regulation language would, and does not attempt to propose section and subsection outline format. Also, this discussion document is not a public hearing draft of a proposed regulation; DEEP will use the discussion document, after considering public feedback, to shape future proposed regulations.

#### **Purpose:**

In light of more recent understanding of the vapor intrusion pathway and substance toxicology, the current Volatilization Criteria in the RSRs may not be protective of human health for most of the 30 volatile substances in Appendices E and F of the RSRs. This discussion document evaluates possible options for addressing the protectiveness of the Volatilization Criteria by updating the vapor intrusion pathway model used for the RSR Volatilization Criteria. There are two main options that are being proposed.

#### **Background:**

The RSR Volatilization Criteria were developed to identify situations where volatile contaminants in groundwater and soil vapor migrate as vapors into an overlying building and result in potential risk to human health from the inhalation of the contaminants by occupants of the building. The target indoor air concentrations (TACs) are used in the development of the RSR Volatilization Criteria. TACs are air concentrations of substances in occupied structures below which chronic exposure is not expected to cause adverse health effects. TACs are based on a combination of exposure factors and the substance toxicology.

The numerical volatilization criteria adopted in 1996 were developed using the vapor transport model available at that time, which was presented in ASTM ES 38-94 “Emergency Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites”, and toxicity

information that was available in 1995. Since then, the Johnson and Ettinger fate and transport model (J&E Model) has been revised to include advection in addition to diffusion as the mechanisms for transport of subsurface contamination into indoor air. Diffusion is the mechanism by which vapor moves from a region of higher concentration to a region of lower concentration; whereas advection is the transport mechanism by which vapor moves to a region where there is a difference in pressure or temperature.

DEEP issued the “[2003 Proposed Revisions to Connecticut’s RSR Volatilization Criteria](#)” (2003 Proposed Revisions) in order to incorporate the revised J&E Model, new toxicological information, and additional information and understanding of the vapor pathway of exposure that became available following the adoption of the RSRs in 1996. Many parties have chosen to use these draft revised criteria as the remedial goal for their cleanup sites.

Subsequent to the 2003 Proposed Revisions, there have been additional vapor intrusion guidance, including:

- Interstate Technology and Regulatory Council (ITRC), issued guidance – [Vapor Intrusion Guidance, January 2007](#) and [Petroleum Vapor Intrusion Guidance, October 2014](#),
- Environmental Protection Agency (EPA), after an extensive notice, comment and review process, issued national guidance on the vapor intrusion pathway which includes advection – [Vapor Intrusion Guidance, June 2015](#) and [Petroleum Vapor Intrusion Guidance, June 2015](#), and
- DEEP and CT Department of Public Health, issued guidance on cardiac and neurological risks *in utero* from very short-term TCE exposure from breathing indoor air. – [TCE Developmental Risks from Indoor Air, February 2015](#).

The following options are being considered for updating the Volatilization Criteria to incorporate updated fate and transport science.

### **Proposed Options for Updating Volatilization Criteria:**

#### **(1) Retain 1996 TACs While Updating to the J&E Model in 2003 Proposed Revisions to Connecticut’s RSR Volatilization Criteria**

Option 1 is to apply the revised J&E Model (which was used in the 2003 Proposed Revisions to Connecticut’s Volatilization Criteria) to the existing TACs in the 1996 RSRs. The revised J&E Model reflects the updated understanding of the groundwater and soil vapor concentrations that would be expected to migrate into indoor air causing it to exceed an existing 1996 TAC. This option would not change the allowable indoor receptor exposure concentrations by maintaining the current 1996 TACs listed in Appendix G of the RSRs; therefore, there would be no change in what is considered the toxicity of the substances. The only change would be in the fate and

transport modeling of those substances in the subsurface. This would result in changes to soil vapor volatilization criteria and groundwater volatilization criteria for some substances.

A potential issue with this option would be that there are some substances which best available science regarding toxicity (including EPA's IRIS database) indicates an increased or decreased risk and so should have their TAC lowered or raised, accordingly. An example of increased risk, thus should have a lower TAC, is [trichloroethylene](#). Examples of a reduced risk, and thus should have their TAC raised, are 1,1-dichloroethylene and, for industrial/commercial exposure, vinyl chloride. This well-documented toxicology information would not be incorporated by using this Option 1.

Also, the 2003 Proposed Revisions do not incorporate more recent understanding of how the petroleum vapor pathway is fundamentally different from other substances due to aerobic degradation. This is discussed further in the Recommendations section of this document.

This option would cause the generated volatilization criteria for some substances to not be as protective as prevailing science suggests they should be, along with overly regulating some other substances for which it is known that they should have their criteria raised.

## **(2) Adoption of 2003 Proposed Revisions to Connecticut's RSR Volatilization Criteria**

Option 2 is to apply the 2003 Proposed Revisions in their entirety. This option would represent a change to the fate and transport of the substances in the subsurface represented by the revised J&E model (same as Option 1), along with limited changes to the toxicity assumptions represented by the TACs (based on the understanding of substance toxicity used in 2003). The volatilization criteria generated by use of this option are the most familiar to the regulated community, since they have been published on DEEP's website since 2003 and many parties have used these criteria as additional polluting substances/alternative criteria in completing remediation at their sites.

An issue with this option would be that the 2003 Proposed Revisions do not incorporate more recent understanding of how the petroleum vapor pathway is fundamentally different due to the presence of aerobic degradation. This is discussed further in the Recommendations section of this document.

Compared to first option, the resulting volatilization criteria would be lower for substances of concern, such as [trichloroethylene](#), while being higher for other substances, such as 1,1-dichloroethylene, based on a better understanding of their toxicity. This would result in a set of criteria that are more protective for some substances while relieving the over-regulation of other substances, in comparison to first option and to the current RSRs.

## **Comparison of Option 1 and Option 2**

Attached to this discussion draft is a table that includes the volatilization criteria resulting from the above options for comparison purposes. Option 1 (1996 TACs input into the 2003 J&E Model) results in volatilization criteria that are consistently lower than the present 1996 RSR volatilization criteria, with the exception of the cases in which the criteria is set by a ceiling value and therefore stays the same. Option 2 (using the 2003 Proposed Revisions in their entirety) results in volatilization criteria that are lower than the present RSR volatilization criteria for many substances, but some of the substances would have criteria that is higher than the present 1996 RSR criteria. More importantly, when comparing Option 1 to Option 2, approximately one-third of the substances have higher criteria in Option 2, reflecting that the improved understanding that the toxicity of those substances is not as conservative as what was determined back in 1996.

## **EPA VISL Calculator**

Also included in the table is a set of criteria that were calculated using the 1996 TACs in the EPA [Vapor Intrusion Screening Level](#) (VISL) Calculator. EPA developed the VISL Calculator to screen for when further evaluation of the vapor intrusion pathway is needed. This exercise was performed to compare those values to the ones generated using the revised J&E model from the 2003 Proposed Revisions and are included for reference purposes only. Due to the fact that it is a screening tool, DEEP is not currently considering using the VISL Calculator generated criteria as an option.

## **Recommendation**

DEEP's recommendation is to revise the RSR volatilization criteria to the criteria from the 2003 Proposed Revisions to Connecticut's Volatilization Criteria (Option 2). This option is more accurate in that it would take into account available information for substances that are known to be less toxic than was thought in 1996, thus allowing some criteria to be higher than computed in the Option 1 and even, in some cases, the current RSR volatilization criteria. Additionally, this option is familiar to the regulated community and thus the impact of the change may be more easily estimated.

Of particular note, the current understanding of Petroleum Vapor Intrusion (PVI) has shown that in the presence of oxygen petroleum soil vapors biodegrade, and therefore attenuate much more rapidly than other volatiles do through diffusion and dispersion alone. When the effects of this bioattenuation are taken into account for petroleum substances, the assumptions used in calculating the proposed 2003 soil vapor criteria (SVVC) from indoor air are valid, but the assumptions used do not support the calculation of the proposed 2003 groundwater volatilization criteria (GWVC). Therefore, an addendum to Option 2 would be to exclude proposed GWVC

for petroleum related substances from the changes recommended in this document, leaving them at the 1996 RSR criteria.

As stated above, Option 2 includes a component on toxicity as was proposed in 2003. Generally, it continues to be DEEP's intent to refer the evaluation of the substance toxicology and exposure to a Science Advisory Panel that will be created as recommended in DEEP's "[Risk-Based Decision Making Recommendation Report](#)". However, for the 30 substances in the RSR Volatilization Criteria, Option 2 is recommended over Option 1 because, among other things, it would not over-regulate some of those substances and, for a substance such as TCE, it would be more up-to-date with current EPA guidance and information on *in utero* risks. The over-all intent of this Discussion Document remains to update the fate and transport component of the Volatilization Criteria (similar to RSR Wave 2 conceptual proposals for Alternative PMC, Alternative GWPC and Alternative SWPC also based on updated fate and transport considerations).

### **Next Steps**

After reviewing public feedback on this Discussion Document, the Department will determine whether or not to incorporate one of the options into the Wave 2 RSR amendment adoption process or a later amendment.

### **References:**

DEEP, [1996 Connecticut Remediation Standard Regulations – Derivation of Volatilization Criteria](#), April 2015

DEEP, [Proposed Revisions – Connecticut's Remediation Standard Regulations Volatilization Criteria](#), March 2003

DEEP, [Remediation Standard Regulations](#), June 27, 2013

DEEP, [Technical Support Document: Recommended Numeric Criteria for Common Additional Polluting Substances and Certain Alternative Criteria](#), December 10, 2015 (Rev. 3/8/16)

EPA, [Vapor Intrusion Screening Level \(VISL\) Calculator 3.4.6](#), January 16, 2016

EPA OSWER, [OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air \(9200.2-154\)](#), June 2015

EPA OUST, [Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites \(510-R-15-001\)](#), June 2015

ITRC, [Vapor Intrusion Pathway: A Practical Guideline](#), January 2007

ITRC, [Petroleum Vapor Intrusion](#), October 2014

**Public Discussion Document**  
**RSR Volatilization Criteria - Fate and Transport Interim Update**  
**Groundwater Volatilization Criteria Comparison Table**

Volatile Substance	Current Criteria		Proposed Option 1		Proposed Option 2		EPA VISL Calculator - For Comparison Only	
	1996 Residential Volatilization Criteria for Groundwater in parts per billion	1996 Industrial/Commercial Volatilization Criteria for Groundwater in parts per billion	1996 TACs in 2003 J&E Model Residential Volatilization Criteria for Groundwater in parts per billion	1996 TACs in 2003 J&E Model Industrial/Commercial Volatilization Criteria for Groundwater in parts per billion	2003 Proposed RSR Revisions Residential Volatilization Criteria for Groundwater in parts per billion	2003 Proposed RSR Revisions Industrial/Commercial Volatilization Criteria for Groundwater in parts per billion	1996 TACs in EPA VISL Calculator Residential Volatilization Criteria for Groundwater in parts per billion	1996 TACs in EPA VISL Calculator Industrial/Commercial Volatilization Criteria for Groundwater in parts per billion
Acetone	50000	50000	50000	50000	50000	50000	50000	50000
Benzene <sup>†</sup>	215	530	130	2000	130	310	14	95
Bromoform	920	3800	300	1200	75	2300	100	170
2-Butanone (MEK)	50000	50000	50000	50000	50000	50000	50000	50000
Carbon Tetrachloride	16	40	11	26	5.3	14	0.89	0.89
Chlorobenzene	1800	6150	1000	3400	1800	23000	160	230
Chloroform	287	710	150	370	26	62	20	20
1,2-Dichlorobenzene	30500	50000	14500	48600	5100	50000	2700	3700
1,3-Dichlorobenzene	24200	50000	12400	41700	4300	50000	*	*
1,4-Dichlorobenzene	50000	50000	48400	50000	1400	3400	8500	12000
1,1-Dichloroethane	34600	50000	20300	50000	3000	41000	2300	3200
1,2-Dichloroethane	21	90	8.6	34	6.5	68	1.9	3.3
1,1-Dichloroethylene	1	6	0.92	3.8	190	920	0.046	0.077
1,2-Dichloropropane	14	60	7.3	30	7.4	58	1.1	1.9
1,3-Dichloropropene	6	25	3.3	13	11	360	*	*
Ethyl benzene <sup>†</sup>	50000	50000	50000	50000	2700	36000	3200	4500
Ethylene dibromide (EDB)	4	16	1.3	5.2	0.3	11	*	*
Methyl-tert-butyl-ether <sup>†</sup>	50000	50000	50000	50000	21000	50000	22000	30000
Methyl isobutyl ketone	50000	50000	29100	50000	13000	50000	15000	21000
Methylene chloride	50000	50000	32000	50000	160	2200	340	340
Styrene	580	2065	300	1000	3100	42000	44	64
1,1,1,2-Tetrachloroethane	12	50	7.8	32	2	64	3.2	5.4
1,1,2,2-Tetrachloroethane	23	100	7	27	1.8	54	2.8	4.7
Tetrachloroethylene	1500	3820	740	1800	340	810	15	15
Toluene <sup>†</sup>	23500	50000	14200	48400	7100	41000	1500	2200
1,1,1-Trichloroethane	20400	50000	13600	46600	6500	16000	1500	2100
1,1,2-Trichloroethane	8000	19600	3000	7200	220	2900	890	890
Trichloroethylene	219	540	140	330	27	67	12	12
Vinyl chloride	2	2	0.50	1.3	1.6	52	0.026	0.043
Xylenes <sup>†</sup>	21300	50000	12400	42300	8700	48000	1500	2100

\* EPA VISL Calculator does not currently contain sufficient chemical information to compute a value for this substance.

<sup>†</sup> Petroleum related substances for which the GWVC could potentially remain at the current 1996 criteria as an addendum to either Option 1 or Option 2.

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**RSR Volatilization Criteria - Fate and Transport Interim Update**  
**Soil Vapor Volatilization Criteria Comparison Table**

Volatile Substance	Current Criteria				Proposed Option 1				Proposed Option 2				EPA VISL Calculator - For Comparison Only			
	1996 Residential Volatilization Criteria for Soil Vapor in parts per million	1996 Residential Volatilization Criteria for Soil Vapor in milligrams per cubic meter	1996 Industrial/Commercial Volatilization Criteria for Soil Vapor in parts per million	1996 Industrial/Commercial Volatilization Criteria for Soil Vapor in milligrams per cubic meter	1996 TACs in 2003 J&E Model Residential Volatilization Criteria for Soil Vapor in parts per million	1996 TACs in 2003 J&E Model Residential Volatilization Criteria for Soil Vapor in milligrams per cubic meter	1996 TACs in 2003 J&E Model Industrial/Commercial Volatilization Criteria for Soil Vapor in parts per million	1996 TACs in 2003 J&E Model Industrial/Commercial Volatilization Criteria for Soil Vapor in milligrams per cubic meter	2003 Proposed RSR Revisions Residential Volatilization Criteria for Soil Vapor in parts per million	2003 Proposed RSR Revisions Residential Volatilization Criteria for Soil Vapor in milligrams per cubic meter	2003 Proposed RSR Revisions Industrial/Commercial Volatilization Criteria for Soil Vapor in parts per million	2003 Proposed RSR Revisions Industrial/Commercial Volatilization Criteria for Soil Vapor in milligrams per cubic meter	1996 TACs in EPA VISL Calculator Residential Volatilization Criteria for Soil Vapor in parts per million	1996 TACs in EPA VISL Calculator Residential Volatilization Criteria for Soil Vapor in milligrams per cubic meter	1996 TACs in EPA VISL Calculator Industrial/Commercial Volatilization Criteria for Soil Vapor in parts per million	1996 TACs in EPA VISL Calculator Industrial/Commercial Volatilization Criteria for Soil Vapor in milligrams per cubic meter
Acetone	2400	5701	8250	19597	270	630	680	1600	57	140	290	690	12	28	16	39
Benzene	1	3	113	361	0.78	2.5	9.4	30	0.78	2.5	1.4	4.6	0.034	0.11	0.23	0.72
Bromoform	1.5	16	6	62	0.16	1.7	0.50	5.2	0.04	0.42	0.98	10	0.0072	0.074	0.012	0.12
2-Butanone (MEK)	2400	7078	8285	24434	270	780	680	2000	130	376	230	690	12	35	17	49
Carbon Tetrachloride	1	6	2.7	17	0.12	0.76	0.22	1.4	0.06	0.38	0.12	0.75	0.0052	0.033	0.0052	0.033
Chlorobenzene	31	143	106	488	3.4	16	8.8	41	6.1	28	60	280	0.15	0.7	0.21	0.97
Chloroform	4.5	22	10.4	51	0.47	2.3	0.85	4.2	0.078	0.38	0.14	0.69	0.021	0.1	0.021	0.1
1,2-Dichlorobenzene	240	1443	818	4918	26	160	67	410	9.2	55	95	570	1.2	7	1.6	9.7
1,3-Dichlorobenzene	240	1443	818	4918	26	160	67	410	9.2	55	95	570	*	*	*	*
1,4-Dichlorobenzene	950	5712	3270	19661	100	630	270	1600	3	18	5.5	33	4.7	28	6.5	39
1,1-Dichloroethane	850	3440	3037	12292	97	390	250	1000	14	58	150	600	4.2	17	5.9	24
1,2-Dichloroethane	1	4	1	4	0.017	0.071	0.054	0.22	0.013	0.053	0.11	0.43	0.00077	0.0031	0.0013	0.0052
1,1-Dichloroethylene	1	4	1	4	0.0093	0.037	0.029	0.11	1.9	7.6	7	28	0.0004	0.0016	0.00068	0.0027
1,2-Dichloropropane	1	5	1	5	0.021	0.097	0.065	0.3	0.021	0.098	0.13	0.58	0.00093	0.0043	0.0016	0.0072
1,3-Dichloropropene	1	5	1	5	0.011	0.050	0.034	0.15	0.035	0.16	0.89	4.0	*	*	*	*
Ethyl benzene	1650	7165	5672	24629	180	790	470	2000	9.3	40	93	400	8.1	35	11	49
Ethylene dibromide (EDB)	1	8	1	8	0.0011	0.0084	0.0033	0.026	0.0005	0.0056	0.007	0.053	*	*	*	*
Methyl-tert-butyl-ether	1000	3605	3415	12312	110	390	280	1000	34	120	73	260	4.7	17	14	49
Methyl isobutyl ketone	140	574	480	1966	15	63	40	160	6.8	28	68	280	0.68	2.8	0.095	3.9
Methylene chloride	1200	4168	2907	10098	9.8	34	18	62	0.65	2.3	6.8	24	0.43	1.5	0.43	1.5
Styrene	8	34	28	119	0.89	3.8	2.3	10	9.3	39	95	400	0.04	0.17	0.056	0.24
1,1,1,2-Tetrachloroethane	1	7	1.5	10	0.036	0.25	0.11	0.77	0.009	0.062	0.22	1.5	0.0016	0.011	0.0026	0.018
1,1,1,2,2-Tetrachloroethane	1	7	1	7	0.0046	0.032	0.014	0.098	0.0012	0.0083	0.028	0.19	0.0002	0.0014	0.00035	0.0024
Tetrachloroethylene	11	75	27	183	1.2	8.3	2.2	15	0.56	3.8	1	6.9	0.054	0.37	0.054	0.37
Toluene	760	2864	2615	9855	84	320	220	810	42	160	180	690	3.7	14	5	19
1,1,1-Trichloroethane	1310	7148	4520	24662	140	790	370	2000	70	380	130	690	6.4	35	9	49
1,1,2-Trichloroethane	40	218	93	507	4.2	23	7.6	42	0.31	1.7	3.1	17	0.18	1	0.18	1
Trichloroethylene	7	38	16	86	0.71	3.8	1.3	7	0.14	0.76	0.26	1.4	0.032	0.17	0.032	0.17
Vinyl chloride	1	3	1	3	0.0085	0.022	0.026	0.068	0.041	0.11	1	2.6	0.00038	0.00097	0.00062	0.0016
Xylenes	500	2192	1702	7461	55	240	140	610	38	170	160	690	2.3	10	3.5	15

\* EPA VISL Calculator does not currently contain sufficient chemical information to compute a value for this substance.

NOTE: Columns 1 & 2 and columns 3 & 4 in each category represent a difference in units only.