# **APPENDIX D**

# **GUIDELINES FOR ASSESSING:**

- PETROLEUM HYDROCARBONS
- POLYCYCLIC AROMATIC HYDROCARBONS
- LEAD
- POLYCHLORINATED DIBENZODIOXINS AND POLYCHLORINATED DIBENZOFURANS
- NON-TRADITIONAL PARAMETERS

# **PETROLEUM HYDROCARBONS**

#### **GUIDELINES FOR ASSESSING PETROLEUM HYDROCARBONS**

This Appendix presents guidelines for a risk-based approach for the assessment and management of soil and groundwater impacted by petroleum hydrocarbons. This approach includes the evaluation of indicator constituents and residual petroleum hydrocarbon constituents.

Petroleum-impacted soil and groundwater shall be assessed using the **TPH Fraction and Indicator Approach** as described by the TPH Criteria Working Group (TPHCWG) (TPGCWG, 1997c). The TPH Fraction and Indicator Approach is based on the assessment of: (1) individual petroleum-related constituents (indicators) using constituent-specific toxicity criteria and physical/chemical properties, **and** (2) total petroleum hydrocarbon (TPH) fractions using fraction-specific toxicity criteria and physical/chemical properties. The indicator constituents and hydrocarbon fractions are identified for different types of releases in Table D-1. In the absence of fraction-specific data, the evaluation of petroleum-impacted media shall include the assessment of: (1) individual petroleum-related constituents (indicators) using constituent-specific toxicity criteria (1) individual petroleum-related constituents (1) individual petroleum-related constituents (1) individual petroleum-related constituents (1) using constituent-specific toxicity criteria (1) individual petroleum-related constituents (1) using constituent-specific toxicity criteria (1) individual petroleum-related constituents (1) using constituent-specific toxicity criteria (1) individual petroleum-related constituents (1) using constituent-specific toxicity criteria (1) individual petroleum-related constituents (1) using constituent-specific toxicity criteria and physical/chemical properties, **and** (2) total petroleum hydrocarbon mixtures (TPH-GRO, TPH-DRO, and/or TPH-ORO).

The hydrocarbon fractions for the TPH Fraction and Indicator Approach were defined based on: (1) environmental behavior and (2) equivalent carbon number. Fractions were defined separately for aliphatics and aromatics due to the great variation in environmental behavior between these two chemical groups. To define the TPH fractions, the potential for individual TPH constituents to leach from soil to groundwater and to volatilize from soil to air was modeled using equations from Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (American Society for Testing and Materials, 1995). The individual constituents were grouped into fractions based on their modeled environmental behavior. Fractions of these TPH constituents were then defined such that the difference in modeled environmental behavior between the fractions was no greater than an order of magnitude. Each of these fractions were then further subdivided based on the equivalent carbon number index. The equivalent carbon number index is related to: (1) the boiling points; and (2) the retention times in a gas chromatographic column of individual TPH constituents, normalized to the n-alkanes. Fate and transport parameter values were assigned to each fraction based on the average values of the individual constituents comprising the fraction (TPHCWG, 1997a). These values are presented in Table D-2. For additional information on how these fractions were defined refer to Total Petroleum Hydrocarbon Working Group Series Volume 3, Selection of Representative TPH Fractions Based on Fate and Transport Considerations (TPHCWG, 1997a).

Oral reference doses (RfD<sub>o</sub>) and inhalation reference concentrations (RfC) were derived for aliphatic and aromatic fractions based on the best available toxicity data for individual TPH constituents, well-defined petroleum mixtures, and whole petroleum products. The RfD<sub>o</sub> and RfC were developed in accordance with EPA methodologies and provide a representative and conservative estimate of each fraction's toxicity. The RfC values (mg/m<sup>3</sup>) were converted to inhalation reference doses (RfD<sub>i</sub>) (mg/kg-day) by dividing by a body weight of 70 kg and multiplying by an inhalation rate of 20 m<sup>3</sup>/day. The RfD<sub>o</sub> and RfD<sub>i</sub> for the TPH fractions are presented in Table D-3. For additional information on how these toxicity values were derived for the TPH fractions refer to Total Petroleum Hydrocarbon Working Group Series Volume 4, Development of Fraction Specific Reference Doses (RfDs) and Reference Concentrations (RfCs) for Total Petroleum Hydrocarbons (TPH) (TPHCWG, 1997b).

The LDEQ approach presented herein differs from the TPH Fraction and Indicator Approach (TPHCWG, 1997b and 1997c) in that: (1) toluene, xylene, and ethylbenzene are evaluated as indicator constituents in lieu of aromatic fractions  $C_{>5}$ - $C_7$  and  $C_{>7}$ - $C_8$ ; and (2) the approach has been modified to include the evaluation of TPH-GRO, TPH-DRO, and TPH-ORO mixture data.

The analytical methods suggested for the identification and quantitation of the designated hydrocarbon fractions include the Massachusetts Department of Environmental Protection's VPH/EPH (volatile petroleum hydrocarbons/extractable petroleum hydrocarbon) Method (http://www.state.ma.us/dep/bwsc/vph eph.htm) and the Texas Commission on Environmental Ouality Method 1006 (http://www.tnrcc.state.tx.us/permitting/analysis.htm#5035). When requesting these analyses, the data user must specify that the carbon ranges to be reported match those found in Table D-1, and that the results be reported on a "wet-weight" basis.

The analytical methods that shall be used for the quantitation of TPH-GRO ( $C_6 - C_{10}$ ) (purgeable), TPH-DRO ( $C_{10} - C_{28}$ ) (extractable), and TPH-ORO (>  $C_{28}$ ) (extractable) (ASTM 1739-95) hydrocarbon mixtures include: (1) SW846 Method 8015B (modified-extraction/GC-FID); (2) more current EPA method; or (3) Texas Commission on Environmental Quality Method 1005 (http://www.tnrcc.state.tx.us/permitting/analysis. htm#5035). For the analysis of PAH constituents, EPA SW846 Method 8310 or EPA SW846 Method 8270 may be used. It is the Submitter's responsibility that the method chosen will achieve SQL that are acceptable under the RECAP based on site-specific conditions, the COC present, and method-specific limitations.

If TPH fractionation data and TPH mixture data have both been collected at an AOI and the two data sets yield different conclusions concerning management of the AOI, then management decisions shall be based on the fractionation data since the fractionation method yields more specific information regarding the TPH constituents present and thus more accurately characterizes site conditions.

Site investigation data collected in accordance with the methods specified in RECAP June 2000 prior to the promulgation of RECAP 2003 shall be considered acceptable for use under the RECAP.

### **TPH Fraction and Indicator Approach**

- **Note**: The indicator constituents **and** TPH fractions shall be identified and quantitated at **all** sites where petroleum hydrocarbons have been released.
- 1. *Indicator Constituents*. The indicator constituents shall be identified and quantitated as individual constituents using appropriate analytical methods. The indicator constituent(s) for petroleum-impacted soils are identified in Table D-1. (Note: benzo[j]fluorene, benzo[ghi]perylene, dibenz[ah]acridine, dibenz[aj]acridine, 7H-dibenzo[cg]carbazole, dibenz[ae]pyrene, dibenzo[ah]pyrene, dibenzo[ai]pyrene, and

3-methylchloanthrene are included as analytes for some EPA methods. These PAHs are not used as indicator constituents for the TPH Fraction and Indicator Approach. Therefore, it is not required that these constituents be evaluated. These constituents will be evaluated as components of the aromatic TPH fractions.)

The AOIC and/or CC for each indicator constituent detected at the AOI shall be compared to the appropriate RS. (Refer to Section 2.8 for guidance on determining the AOIC and/or compliance concentration).

2. *Hydrocarbon Fractions (or Hydrocarbon Mixtures)*. The TPH Fraction and Indicator Approach hydrocarbon fractions shall be identified and quantitated using an appropriate analytical method (refer to the previous page for suggested analytical methods). In lieu of identifying and quantitating the hydrocarbon fractions designated by the TPH Fraction and Indicator Approach, TPH-GRO ( $C_6-C_{10}$ ), TPH-DRO ( $C_{10}-C_{28}$ ) (extractable), and/or TPH-ORO ( $C_{28}-C_{>35}$ ) (extractable) hydrocarbon mixtures may be identified and quantitated using an appropriate analytical method (refer to the previous page for suggested analytical method (refer to the previous page for suggested analytical method fractions and hydrocarbon mixtures that shall be identified and quantitated for different types of petroleum releases are presented in Table D-1.

The AOIC and/or CC detected for each hydrocarbon fraction or hydrocarbon mixture at the AOI shall be compared to the limiting SS or RS. The total concentration of petroleum hydrocarbons present in each impacted medium at an AOI shall be less than or equal to 10,000 ppm. The total petroleum hydrocarbon concentration shall be determined by summing the AOIC or compliance concentration for each aliphatic and aromatic hydrocarbon fraction detected in the medium of concern at the AOI or by summing the AOIC or compliance concentration for each hydrocarbon mixture detected in the medium of concern at the AOI.

### **Odors/Aesthetics**

The Submitter may be required to remediate to petroleum hydrocarbon concentrations that are lower than the concentrations specified by this Program if compliance with MO-1, MO-2, or MO-3 RS results in a visual or odor nuisance that compromises the aesthetic value and/or land use of the site. For example, for a release of diesel fuel in an industrial area, where all the indicator constituents for petroleum-impacted soils are met and the TPH-DRO hydrocarbon concentration is less than or equal to the RS but a constant, objectionable odor is evident, the submitter may recommend and complete excavation of the affected soils to aesthetically acceptable concentrations. This new clean up goal would be governed by the aesthetic appearance and odor of the soil only, **not a revised risk-based RS**. The Submitter should determine the aesthetic concentration and propose a plan to address the soils in an appropriate manner.

### SS and RS for TPH-GRO, TPH-DRO, and TPH-ORO

For the generation of SS and RS for TPH-GRO, TPH-DRO, and TPH-ORO for Tables 1, 2, and 3, the aliphatic or aromatic fraction with the most protective RfD was used to represent the entire TPH mixture [gasoline (TPH-GRO), diesel (TPH-DRO), and oil (TPH-ORO)] was represented. TPH-GRO is represented by the RfD for Aromatics  $C_{>8}$ - $C_{12}$  (RfD<sub>0</sub> of 0.04 mg/kg-d); RfD<sub>1</sub> of 0.06 mg/kg-d). TPH-DRO is represented by the RfD for Aromatics  $C_{>10}$ - $C_{21}$  (RfD<sub>0</sub> of 0.03 mg/kg-d; RfD<sub>1</sub> of 0.06 mg/kg-d). TPH-ORO is represented by the RfD for Aromatics  $C_{>10}$ - $C_{21}$  (RfD<sub>0</sub> of 0.03 mg/kg-d; RfD<sub>1</sub> of 0.06 mg/kg-d).

### **Adjusting TPH RS for Additivity**

The critical effects/target organs for the TPH-related constituents are presented in Table D-4. When adjusting for additive health effects, the TPH fractions and mixtures should be treated as **individual** constituents. It should be noted that: 1) the RfD for aliphatic fractions  $C_{>8}$ - $C_{10}$ ,  $C_{>10}$ - $C_{12}$ , and  $C_{>12}$ - $C_{16}$  account for additive health effects and therefore, for the purposes of adjusting for additivity, these three fractions should be treated as one fraction – not three fractions; 2) the RfD for aromatic fractions  $C_{>8}$ - $C_{10}$ ,  $C_{>10}$ - $C_{12}$ , and  $C_{>12}$ - $C_{16}$  account for additive health effects and therefore, for the purposes of adjusting for additive health effects and therefore, for the purposes of adjusting for additive health effects and therefore, for the purposes of adjusting for additive health effects and therefore, for the purposes of adjusting for additive health effects and therefore, for the purposes of adjusting for additivity, these three fractions should be treated as one fraction – not three fractions should be treated as one fraction – not three fractions  $C_{>16}$ - $C_{21}$  and  $C_{>21}$ - $C_{35}$  account for additivity and therefore, for the purposes of adjusting for additivity, these two fractions should be treated as one fraction – not two fractions. For additional guidance on adjusting RS to account for additive health effects refer to Appendix G.

# Additivity Example: Gasoline release - adjusting the Soil<sub>i</sub> to account for additive health effects:

- **COC present:** ethylbenzene, toluene, aliphatics C<sub>>6</sub>-C<sub>8</sub>, aliphatics C<sub>>8</sub>-C<sub>10</sub>, aliphatics C<sub>>10</sub>-C<sub>12</sub>, aromatics C<sub>>8</sub>-C<sub>10</sub> and aromatics C<sub>>10</sub>-C<sub>12</sub>
- **Targets:** Liver (L): 3 COC (ethylbenzene, toluene, aliphatics C<sub>>8</sub>-C<sub>12</sub>) Kidney (K): 3 COC (ethylbenzene, toluene, aliphatics C<sub>>6</sub>-C<sub>8</sub>) Body weight (BW): 1 COC (aromatics C<sub>>8</sub>-C<sub>12</sub>)

### Adjustment of Soil<sub>i</sub>:

COC	Table 3 Soil <sub>i</sub>	Appendix H Worksheet 5 Soil <sub>i</sub>	Target	Adjusted Soil <sub>i</sub>
Ethylbenzene	13,000		K,L	13,000/3 = <b>4333</b>
Toluene	83,000		K,L	83,000/3 = 27,666
Aliphatics $C_{>6}$ - $C_8$	10,000	82,800	K	82,800/3 = 27,333 (27,333 > 10,000 so use <b>10,000</b> )
Aliphatics C <sub>&gt;8</sub> -C <sub>10</sub>	8800		L	8800/3 = 2933
Aliphatics $C_{>10}$ - $C_{12}$	10,000	18,600	L	18,600/3 = <b>6200</b>
Aromatics	5,000		BW	5000

$C_{>8}$ - $C_{10}$				
Aromatics	10,000	10,100	BW	10,000
$C_{>10}$ - $C_{12}$				

Note: Additivity does not apply to a Soil<sub>i</sub> RS based on an analytical quantitation limit, a Department-approved background level, or the 10,000 mg/kg cap. It should be noted that the sum of residual TPH fraction concentrations remaining in soil shall not exceed 10,000 mg/kg.

### Table D-1

### Indicator Compounds, Hydrocarbon Fractions<sup>1</sup> and Hydrocarbon Mixtures

Indicator Compound	gasoline	jet fuel <sup>2</sup> (JP-8)	kerosene	Diesel, light fuel oils	heavy fuel oils	crude oil	highly refined base oils (hydraulic fluid) <sup>3</sup>	used motor oil, lubricating oil	unknown
Benzene	Х								Х
Toluene	Х								Х
Ethylbenzene	Х								Х
Xylene	Х								Х
Acenaphthene				Х	Х	Х		Х	Х
Acenaphthylene				Х	Х	Х		Х	Х
Anthracene				Х	Х	Х		Х	Х
Benzo(a)pyrene				Х	Х	Х		Х	Х
Chrysene				Х	Х	Х		Х	Х
Dibenz(a,h)anthracene				Х	Х	Х		Х	Х
Indeno(1,2,3-cd)pyrene				Х	Х	Х		Х	Х
Benzo(k)fluoranthene				Х	Х	Х		Х	Х
Benzo(b)fluoranthene				Х	Х	Х		Х	Х
Benzo(a)anthracene				Х	Х	Х		Х	Х
Fluoranthene				Х	Х	Х		Х	Х
Fluorene				Х	Х	Х		Х	Х
Naphthalene				Х	Х	Х		Х	Х
2-Methylnaphthalene				Х	Х	Х		Х	Х
Phenanthrene				Х	Х	Х		Х	Х
Pyrene				Х	Х	Х		Х	Х
Lead (inorganic)	$X^4$								$X^4$
Metals								Х	
Methyl tertbutyl ether	$X^4$								$X^4$
Methyl ethyl ketone	$X^4$								$X^4$
Methyl isobutyl ketone	$X^4$								$X^4$
Aliphatics C <sub>&gt;6</sub> - C <sub>8</sub>	X <sup>5</sup>	Х	X <sup>7</sup>			X <sup>6</sup>			X <sup>6</sup>
Aliphatics C <sub>&gt;8</sub> - C <sub>10</sub>	X <sup>5</sup>	Х	X <sup>7</sup>			X <sup>6</sup>			X <sup>6</sup>
Aliphatics C <sub>&gt;10</sub> - C <sub>12</sub>		Х	X <sup>7</sup>	X <sup>8</sup>		X <sup>6</sup>			X <sup>6</sup>
Aliphatics C <sub>&gt;12</sub> - C <sub>16</sub>		Х	X <sup>7</sup>	X <sup>8</sup>		X <sup>6</sup>	X <sup>9</sup>		X <sup>6</sup>
Aliphatics C <sub>&gt;16</sub> - C <sub>35</sub>		Х		X <sup>8</sup>	X <sup>9</sup>	X <sup>6</sup>	X <sup>6</sup>	$X^{10}$	X <sup>6</sup>
Aromatics C <sub>&gt;8</sub> - C <sub>10</sub>	X <sup>5</sup>	Х	$X^7$			X <sup>6</sup>			X <sup>6</sup>
Aromatics C <sub>&gt;10</sub> - C <sub>12</sub>		Х	$X^7$	X <sup>8</sup>		X <sup>6</sup>			X <sup>6</sup>
Aromatics C <sub>&gt;12</sub> - C <sub>16</sub>		Х	$X^7$	X <sup>8</sup>		X <sup>6</sup>	X <sup>6</sup>		X <sup>6</sup>
Aromatics C <sub>&gt;16</sub> - C <sub>21</sub>		Х		X <sup>8</sup>	X <sup>9</sup>	X <sup>6</sup>	X <sup>6</sup>		X <sup>6</sup>
Aromatics C <sub>&gt;21</sub> - C <sub>35</sub>		Х			X <sup>9</sup>	X <sup>6</sup>	X <sup>6</sup>	$X^{10}$	$X^6$
TPH–GRO $C_6 - C_{10}$	X <sup>11</sup>	X 6	X <sup>11</sup>			X <sup>11</sup>			$X^6$
TPH–DRO $C_{10} - C_{28}^{12}$		X 6	X <sup>13</sup>	X <sup>13</sup>	X <sup>13</sup>	X <sup>13</sup>	X <sup>13</sup>		X <sup>6</sup>
TPH-ORO $C_{>28}^{12}$		X <sup>6</sup>			X <sup>14</sup>	X <sup>14</sup>	X <sup>14</sup>	$X^{14}$	$X^6$

<sup>1</sup>ASTM (1995) and TPH Criteria Working Group (1998); under certain site-specific conditions, the Department may require that additional indicator constituents be identified for evaluation; for petroleum mixtures not identified in Table D-1, indicator compounds and hydrocarbon ranges shall be identified by the Submitter and approved by the Department.

<sup>2</sup>For JP-7 (C<sub>10</sub>-C<sub>17</sub>), the hydrocarbon fractions shall include aliphatic and aromatic C<sub>>8</sub>-C<sub>10</sub>, C<sub>>10</sub>-C<sub>12</sub>, C<sub>>12</sub>-C<sub>16</sub>, and C<sub>>16</sub>-C<sub>35</sub>. For JP-5, the indicator compounds shall include benzene, toluene, ethylbenzene, and xylene and the hydrocarbon fractions shall include aliphatic and aromatic C<sub>>8</sub>-C<sub>10</sub>, C<sub>>10</sub>-C<sub>12</sub>, C<sub>>12</sub>-C<sub>16</sub>, and C<sub>>16</sub>-C<sub>35</sub>.

<sup>3</sup>Applies to oils formulated with highly refined base oils including hydraulic fluids (Mineral-oil based hydraulic fluids, *Toxicological Profile for Mineral Oil Hydraulic Fluids, Organophosphate Ester Hydraulic Fluids, and Polyalphaolefin Hydraulic Fluids*, ATSDR 1994), motor oils, industrial oils, and automatic transmission fluid-type oils (i.e., severely refined base oils).

<sup>4</sup>When suspected to be present.

- <sup>5</sup>TPH-GRO may be used instead of Aliphatics  $C_{>6}$   $C_8$ , Aliphatics  $C_{>8}$   $C_{10}$ , and Aromatics  $C_{>8}$   $C_{10}$ .
- <sup>6</sup>TPH-GRO, TPH-DRO, and TPH-ORO may be used instead of Aliphatics  $C_{>6}$   $C_8$ , Aliphatics  $C_{>8}$   $C_{10}$ , Aliphatics  $C_{>10} C_{12}$ , Aliphatics  $C_{>12}$   $C_{16}$ , Aliphatics  $C_{>16} C_{35}$ , Aromatics  $C_{>8}$   $C_{10}$ , Aromatics  $C_{>10}$   $C_{12}$ , Aromatics  $C_{>10}$   $C_{10}$   $C_{$
- <sup>7</sup>TPH-GRO and TPH-DRO may be used instead of Aliphatics  $C_{>6}$   $C_8$ , Aliphatics  $C_{>8}$   $C_{10}$ , Aliphatics  $C_{>10}$   $C_{12}$ , Aliphatics  $C_{>12}$   $C_{16}$ , Aliphatics  $C_{>16}$   $C_{35}$ , Aromatics  $C_{>8}$   $C_{10}$ , Aromatics  $C_{>10}$   $C_{12}$ , Aromatics  $C_{>12}$   $C_{16}$ , Aromatics  $C_{>16}$   $C_{21}$ , and Aromatics  $C_{>21}$   $C_{35}$ .
- <sup>8</sup>TPH-DRO may be used instead of Aliphatics  $C_{>10} C_{12}$ , Aliphatics  $C_{>12} C_{16}$ , Aliphatics  $C_{>16} C_{35}$ , Aromatics  $C_{>10} C_{12}$ , Aromatics  $C_{>21} C_{35}$ .
- <sup>9</sup>TPH-DRO and TPH-ORO may be used instead of Aliphatics  $C_{>10} C_{12}$ , Aliphatics  $C_{>12} C_{16}$ , Aliphatics  $C_{>16} C_{35}$ , Aromatics  $C_{>10} C_{12}$ , Aromatics  $C_{>10} C_{12}$ , Aromatics  $C_{>12} C_{16}$ , Aromatics  $C_{>16} C_{21}$ , and Aromatics  $C_{>21} C_{35}$ .
- <sup>10</sup>TPH-ORO may be used instead of Aliphatics  $C_{>16} C_{35}$  and Aromatics  $C_{>21} C_{35}$ .
- <sup>11</sup>Aliphatics  $C_{>6}$   $C_8$ , Aliphatics  $C_{>8}$   $C_{10}$ , and Aromatics  $C_{>8}$   $C_{10}$  may be used instead of TPH-GRO.
- <sup>12</sup>Extractable.
- <sup>13</sup>Aliphatics  $C_{>10} C_{12}$ , Aliphatics  $C_{>12} C_{16}$ , Aliphatics  $C_{>16} C_{35}$ , Aromatics  $C_{>10} C_{12}$ , Aromatics  $C_{>12} C_{16}$ , Aromatics  $C_{>16} C_{21}$ , and Aromatics  $C_{>21} C_{35}$  may be used instead of TPH-DRO.
- <sup>14</sup>Aliphatics  $C_{>16} C_{35}$  and Aromatics  $C_{>21} C_{35}$  may be used instead of TPH-ORO.

### Table D-2

Fraction	Boiling Point	Molecular Weight	Solubility (mg/l)	Vapor Pressure	Henry's Law Constant	log Koc (ml/g)
	(°C)	(g/mole)		(atm)	$(\text{cm}^3/\text{cm}^3)$	
C <sub>5</sub> -C <sub>6</sub> Aliphatics	5.1E+01	8.1E+01	3.6E+01	3.5E-01	3.3E+01	2.9E+00
$C_{>6}$ - $C_8$ Aliphatics	9.6E+01	1.0E+02	5.4E+00	6.3E-02	5.0E+01	3.6E+00
C <sub>&gt;8</sub> -C <sub>10</sub> Aliphatics	1.5E+02	1.3E+02	4.3E-01	6.3E-03	8.0E+01	4.5E+00
C <sub>&gt;10</sub> -C <sub>12</sub> Aliphatics	2.0E+02	1.6E+02	3.4E-02	6.3E-04	1.2E+02	5.4E+00
C <sub>&gt;12</sub> -C <sub>16</sub> Aliphatics	2.6E+02	2.0E+02	7.6E-04	4.8E-05	5.2E+02	6.7E+00
C <sub>&gt;16</sub> -C <sub>21</sub> Aliphatics	3.2E+02	2.7E+02	1.3E-06	1.1E-06	4.9E+03	8.8E+00
$C_{>8}$ - $C_{10}$ Aromatics	1.5E+02	1.2E+02	6.5E+01	6.3E-03	4.8E-01	3.2E+00
C <sub>&gt;10</sub> -C <sub>12</sub> Aromatics	2.0E+02	1.3E+02	2.5E+01	6.3E-04	1.4E-01	3.4E+00
C <sub>&gt;12</sub> -C <sub>16</sub> Aromatics	2.6E+02	1.5E+02	5.8E+00	4.8E-05	5.3E-02	3.7E+00
$C_{>16}$ - $C_{21}$ Aromatics	3.2E+02	1.9E+02	6.5E-01	1.1E-06	1.3E-02	4.2E+00
C <sub>&gt;21</sub> -C <sub>35</sub> Aromatics	3.4E+02	2.4E+02	6.6E-03	4.4E-10	6.7E-04	5.1E+00

## **Physical/Chemical Properties for Hydrocarbon Fractions**<sup>1</sup>

<sup>1</sup>TPH Criteria Working Group, 1997a.

### Table D-3 $^1$

### Petroleum Hydrocarbon Fraction-Specific

### **Chronic Reference Doses**

Carbon Range <sup>2</sup>	Oral RfD	Inhalation RfD	Target Organ/
	(mg/kg-day)	(mg/kg-day)	<b>Critical Effect</b>
Aliphatics $C_{>6}$ - $C_8^3$	5.0	5.3	kidney
Aliphatics C <sub>&gt;8</sub> -C <sub>16</sub>	0.1	0.3	liver, hematological system
Aliphatics C <sub>&gt;16</sub> -C <sub>35</sub>	2.0	NA <sup>4</sup>	liver
Aromatics C <sub>&gt;8</sub> -C <sub>16</sub>	0.04	0.06	decreased body weight
Aromatics C <sub>&gt;16</sub> -C <sub>35</sub>	0.03	NA	kidney

<sup>1</sup>TPHCWG, 1997b.

<sup>2</sup>Equivalent carbon number range as defined in TPHCWG, 1997a.

<sup>3</sup>If the n-hexane concentration is < 53% (as in commercial hexane) a RfD of 5.0 mg/kg-d shall be used. If the n-hexane concentration is > 53%, a composition-weighted RfD shall be developed using 0.06 mg/kg-d for the n-hexane portion and 2.0 mg/kg-d for the remainder of the mass.

 $^{4}$ NA = Not Available.

### Table D-4

### Critical Effects for the Assessment of Additive Health Effects for Petroleum Hydrocarbon Releases<sup>1</sup>

CONSTITUENT	CAS #	TARGET ORGAN(S)/CRITICAL EFFECT(S) <sup>2</sup>
Gasoline:		
Benzene	71-43-2	Bone marrow toxicity (lymphocytopenia) <sup>3</sup>
Ethyl benzene	100-41-4	Liver toxicity; Kidney toxicity; Fetal effects (skeletal
		abnormalities)
Toluene	108-88-3	Liver effects (change in weight); Kidney effects (change in
		weight); Central nervous system effects (decreased concentration-
		response relationship); Nasal cavity (degeneration of epithelium)
Xylene (mixed)	1330-20-7	Central nervous system effects (impaired motor coordination);
	4	Decreased body weight; Increased mortality
Aliphatics $C_6$ - $C_8$	NA <sup>4</sup>	Kidney effects
Aliphatics $C_{>8}$ - $C_{16}$	NA	Liver effects; Hematological system effects
Aromatics $C_{>8}$ - $C_{16}$	NA	Decreased body weight
TPH-GRO	NA	Kidney effects; Liver effects; Hematological system effects;
		Decreased body weight
Diesel:		
Acenaphthene	83-32-9	Liver toxicity
Anthracene	120-12-7	No observed effects
Fluoranthene	206-44-0	Kidney effects; Liver effects
Fluorene	86-73-7	Hematological effects
Naphthalene	91-20-3	Decreased body weight; Nasal cavity effects
Pyrene	129-00-0	Kidney effects
Aliphatics $C_{>8}$ - $C_{16}$	NA	Liver effects; Hematological system effects
Aliphatics C <sub>&gt;16</sub> -C <sub>35</sub>	NA	Liver effects
Aromatics $C_{>8}$ - $C_{16}$	NA	Decreased body weight
Aromatics $C_{>16}$ - $C_{35}$	NA	Kidney effects
TPH-DRO	NA	Kidney effects; Liver effects; Hematological system effects;
		Decreased body weight
Oil (used motor oil, lubricating oil	):	
Acenaphthene	83-32-9	Liver toxicity
Anthracene	120-12-7	No observed effects
Fluoranthene	206-44-0	Kidney effects; Liver effects
Fluorene	86-73-7	Hematological effects
Naphthalene	91-20-3	Decreased body weight; Nasal cavity effects
Pyrene	129-00-0	Kidney effects
Aliphatics C <sub>&gt;16</sub> -C <sub>35</sub>	NA	Liver effects
Aromatics C <sub>&gt;16</sub> -C <sub>35</sub>	NA	Kidney effects
TPH-ORO	NA	Kidney effects; Liver effects
Additives:		
Methyl ethyl ketone	78-93-3	Fetal effects (decreased birth weight)
Methyl isobutyl ketone	108-10-1	NA
MTBE (methyl tert-butyl ether)	1634-04-4	Liver effects; Kidney; Ocular effects

<sup>1</sup>Data were obtained from EPA's Integrated Risk Information System and Health Effects Assessment Summary Tables; includes target organs/critical effects for the ingestion and inhalation routes of exposure (where available).

<sup>2</sup>The target organs/critical effects on which the reference dose(s) is based.

<sup>3</sup>NCEA; RAIS June 2003.

<sup>4</sup>Not applicable or not available.

### References

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# POLYCYCLIC AROMATIC HYDROCARBONS

### GUIDELINES FOR ASSESSING POLYCYCLIC AROMATIC HYDROCARBONS

**Carcinogens.** Seven Polycyclic Aromatic Hydrocarbons (PAH) constituents have been assigned weight of evidence judgments of Group B2, probable human carcinogen. These constituents include benzo[a]pyrene, benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene. A cancer slope factor is currently available only for benzo[a]pyrene. The remaining carcinogenic PAH shall be assessed using cancer slope factors developed based on their respective "estimated order of potential potency" relative to the potency of benzo[a]pyrene. These relative potencies should be applied only to the assessment of carcinogenic hazards associated with the ingestion of PAH (*Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*, EPA 1993).

Constituent	Relative	Oral Slope Factor <sup>2</sup>	Inhalation Slope Factor <sup>2</sup>
	Potency <sup>1</sup>	(mg/kg-day)	(mg/kg-day) <sup>-1</sup>
benzo[a]pyrene	1.0	7.3E-00	3.1E+00
benz[a]anthracene	0.1	7.3E-01	3.1E-01
benzo[b]fluoranthene	0.1	7.3E-01	3.1E-01
benzo[k]fluoranthene	0.01	7.3E-02	3.1E-02
chrysene	0.001	7.3E-03	3.1E-03
dibenz[a,h]anthracene	1.0	7.3E-00	3.1E+00
indeno[1,2,3-cd]pyrene	0.1	7.3E-01	3.1E-01

<sup>1</sup>Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons, EPA 1993. <sup>2</sup>EPA Region 6 Human Health Medium-Specific Screening Levels.

**Noncarcinogens.** Surrogate RfD have been assigned to the following noncarcinogenic PAH constituents based on similarities in chemical structure and physiological activity:

Constituent	RfDo	RfD <sub>i</sub>	Reference	Surrogate
acenaphthylene	6E-02	$NA^1$	IRIS <sup>2</sup>	acenaphthene
2-methylnaphthalene	2E-02	8.6E-04	IRIS	naphthalene
phenanthrene	3E-01	NA	IRIS	anthracene

<sup>1</sup>Not available.

<sup>2</sup>Integrated Risk Information System, EPA.

# LEAD

### **GUIDELINES FOR ASSESSING INORGANIC LEAD**

Health risks associated with exposure to inorganic lead are not assessed using the traditional risk assessment methodology based on the use of toxicity values (RfD, RfC, SF). Rather, lead exposure is assessed using the Integrated Exposure Uptake Biokinetic Model (IEUBK) (pub. #9285.7-15-2, PB93-963511) or the Adult Lead Cleanup Level Model.

The IEUBK model is a pharmacokinetic model that integrates exposure from lead in air, water, soil, dust, diet, and paint. This model estimates blood lead levels associated with exposure under a residential scenario (child receptor) to determine an acceptable soil lead concentration for residential land use. Using standard EPA default parameters recommended in the Guidance Manual for IEUBK Model for Lead in Children (EPA 1994), the resulting soil concentration for lead is 400 mg/kg for a residential land use scenario. According to EPA guidance, it is expected that a soil lead concentration of 400 mg/kg will limit the probability that blood lead levels will exceed 10 ug/dl to no more than 5 percent for a child receptor under a residential exposure scenario. In accordance with EPA guidelines, the MO-1 and MO-2 risk-based Soil<sub>ni</sub> for lead has been set at 400 mg/kg. The value of 400 mg/kg is based on an assumed outdoor air concentration of 0.10 ug/m<sup>3</sup> and a drinking water concentration of 4 ug/l (EPA 1994). The final non-industrial RS applied at the AOI shall consider Soil<sub>GW</sub> and Soil<sub>sat</sub>.

For non-industrial land use scenarios, lead exposure should be assessed using the Adult Lead Model in accordance with *Recommendations for the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil* (TRWR; EPA 1996). This model focuses on estimating fetal blood lead concentrations in pregnant women exposed to lead contaminated soils in a commercial/industrial setting. In accordance with EPA guidelines, the Adult Lead Model and standard EPA default parameters recommended by EPA Region VI were used to develop the SO Soil<sub>SSi</sub>, MO-1 Soil<sub>i</sub>, and MO-2 Soil<sub>i</sub> of 1,400 mg/kg for lead. The final industrial RS applied at the AOI shall consider Soil<sub>GW</sub> and Soil<sub>sat</sub>. The adult lead model and default assumptions are presented below.

Site-specific exposure data may used under MO-3 for the assessment of lead exposure for residential and industrial land use scenarios. Under MO-2, site specific data may be used for the exposure concentration model inputs for air, drinking water, and soil/dust. In the absence of site-specific data, EPA default values shall be used.

	$Soil_{i}(\mu g / g) = \frac{(PbB_{95} fetal / (R x(GSD_{i})^{1.645})) - PbB0}{BKSF x ((IR_{s} x AF_{s} x EF_{s} / 365) + (K_{sd} x IR_{d} x AF_{d} x EF_{d} / 365))}$	
Parameter	Definition (units)	Default <sup>2</sup>
PbB <sub>95</sub> fetal	95 <sup>th</sup> Percentile PbB in Fetus ( $\mu g/dL$ )	10
R	Mean Ratio of Fetal to Maternal PbB	0.9
GSD <sub>i</sub>	Individual Geometric Standard Deviation	1.8
PbB0	Baseline Blood Lead Value (µg/dL)	2.0
BKSF	Biokinetic Slope Factor (µg/dL per µg/day)	0.4
IR <sub>s</sub>	Soil Ingestion Rate (g/day)	0.05
IR <sub>d</sub>	Dust Ingestion Rate (g/day)	0
K <sub>sd</sub>	Ratio of Concentration in Dust to that in Soil	0.7
EFs	Soil Exposure Frequency (days/yr)	219
EFd	Dust Exposure Frequency (days/yr)	219
AFs	Absolute Absorption Fraction of Lead in Soil	0.12
AF <sub>d</sub>	Absolute Absorption Fraction of Lead in Dust	0.12

### Adult Lead Exposure Model<sup>1</sup> - Commercial/Industrial Land Use

<sup>1</sup>Recommendations for the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil (TRWR; EPA 1996). <sup>2</sup> EPA Region VI, 2003.

## POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

#### GUIDELINES FOR ASSESSING POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

Polychlorinated dibenzodioxins (PCDD) and dibenzofurans (PCDF) shall be evaluated using Toxic Equivalency Factors (TEF) that indicate an order of magnitude estimate of the toxicity of a specific congener relative to the most toxic congener, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). The TEF values in combination with site characterization data shall be used to calculate a toxic equivalent concentration (TEQ) in each medium of concern using the equation and TEF values presented below. The TEQ for each medium shall be compared to the SS or RS for TCDD.

$$TEQ = \sum_{n1} [PCDD_i \times TEF_i] + \sum_{n2} [PCDF_i \times TEF_i].$$

where:

Parameter	Definition
TEQ	Toxic equivalent concentration
PCDD	Concentration of PCDD congener in medium
PCDF	Concentration of PCDF in congener in medium
TEF	Congener-specific toxic equivalent factor

The TEF that shall be used to calculate the TEQ are as follows:

Congener	TEF <sup>1</sup>
Dioxins	
2,3,7,8-TCDD	1
1,2,3,7,8-PentaCDD	0.1
1,2,3,4,7,8-HexaCDD	0.1
1,2,3,6,7,8-HexaCDD	0.1
1,2,3,7,8,9-HexaCDD	0.1
1,2,3,4,6,7,8-HeptaCDD	0.01
OctaCDD	0.0001
Furans	
2,3,7,8-TetraCDF	0.1
1,2,3,7,8-PentaCDF	0.05
2,3,4,7,8-PentaCDF	0.5
1,2,3,4,7,8-HexaCDF	0.1
1,2,3,6,7,8-HexaCDF	0.1
1,2,3,7,8,9-HexaCDF	0.1
2,3,4,6,7,8-HexaCDF	0.1
1,2,3,4,6,7,8-HeptaCDF	0.01
1,2,3,4,7,8,9-HeptaCDF	0.01
OctaCDF	0.0001

<sup>1</sup>*Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife.* Van den Berg, Martin, et.al. Environmental Health Perspectives, Volume 106; Number 12, December 1998; Federal Register, May 18, 2000, Volume 65, Number 97, Page 31696.

# **NON-TRADITIONAL PARAMETERS**

#### NON-TRADITIONAL PARAMETERS

Non-traditional parameters include those constituents or physical/chemical parameters (e.g. chlorides, sulfates, pH, temperature, etc.) for which toxicity data are not available and thus cannot be evaluated using traditional risk assessment/RECAP methods. Non-traditional parameters shall be evaluated under MO-2 or MO-3. RS for these constituents (or physical/chemical parameters) shall consider, where appropriate and feasible, protection of human health, ecological receptors, livestock, crops, and vegetation; prevention of constituent migration and cross-media transfer; protection of beneficial uses of the medium of concern; protection of above ground and subsurface structures; and protection of resource aesthetics. Where appropriate, an environmental fate and transport analysis may be required by the Department to evaluate potential future impacts to health and/or the environment. An ecological checklist (RECAP Form 18) shall be completed to evaluate the need for an ecological risk assessment.

The evaluation of these parameters is highly dependent on professional judgement and all proposed RS shall be subject to Department approval. It is recommended that a workplan be submitted to the Department for approval prior to managing an AOI impacted by a non-traditional constituent or other parameter that may produce adverse environmental effects. A RS proposed for a non-traditional parameter shall be accompanied by appropriate supporting documentation and references. A RS for a non-traditional parameter shall not result in soil that exhibits hazardous waste characteristics of ignitability, corrosivity, or reactivity as defined in the Hazardous Waste Regulations (LAC 33:V). Prior to the development and application of a RS for a non-traditional parameter, the impacted medium under investigation shall be in declining conditions (i.e., the constituent mass is not increasing, the source of the release has been mitigated, and the area of constituent concentrations likely to be of concern is not expanding).

Non-traditional parameters shall be evaluated in accordance with the guidelines presented below as may be applicable.

- 1. Identify all available Applicable or Relevant and Appropriate Requirements (ARAR) (e.g., secondary MCL). Of the available ARAR, select the ARAR that is most appropriate for the evaluation of site-specific conditions and health and environmental concerns identified at the AOI. Where appropriate, consider the beneficial use of the medium of concern (e.g., groundwater used for irrigation);
- 2. Consider the protection of resource aesthetics (i.e., soil saturation level, water solubility, odor thresholds, taste, visual, etc.);
- 3. Consider all environmental fate and transport pathways especially those relating to exposure to human or ecological receptors and constituent migration and cross-media transfer;
- 4. Consider protection of vegetation (e.g., native surface cover) and/or the ability to grow crops;

- 5. Consider the Department-approved background concentration in accordance with Section 2.13 (e.g., for the evaluation of cross-media transfer, the naturally-occurring background chloride concentration of a receiving surface water body may be used as the SS or RS for the evaluation of chloride in a Groundwater 3 zone);
- 6. Based on the information obtained in steps 1, 2, 3, 4, and 5 identify a RS that adequately addresses the health and/or environmental concerns at the AOI;
- 7. Determine the AOIC or CC in accordance with Section 2.8; and
- 8. Compare the AOIC to the RS:

If the AOIC is less than or equal to the RS, then typically no further action at this time shall be required for the medium of concern.

If the AOIC is greater than the RS, then the AOI shall be further evaluated under a higher tier or the medium of concern shall be remediated to the RS.

If the SS or RS is less than the analytical quantitation limit, then a Department-approved quantitation limit shall serve as the SS or RS.