APPENDIX A

METHODS FOR THE DEVELOPMENT OF SCREENING STANDARDS AND MO-1, MO-2, AND MO-3 RECAP STANDARDS

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A1.0 SOIL STANDARDS

The RECAP Soil Standards include $Soil_{ssni}$, $Soil_{ssi}$, $Soil_{SSGW}$, $Soil_{ni}$, $Soil_{i}$, $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$, $Soil_{GW3NDW}$, and $Soil_{sat}$. The Soil Screening Standards (Table 1), Management Option 1 RECAP Standards (Table 2), and the Appendix G MO-2 RECAP Standards (Tables G1 – G7) are based on: 1) the equations and input values presented in this appendix; 2) toxicity values selected in accordance with the hierarchy defined in Section 2.4 and Appendix D Table H-4 for the TPH components; 3) a target cancer risk and target hazard quotient as specified in Section 2.5; 4) *EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites* calculator physical/chemical properties and TPHCWG physical/chemical properties for aliphatic and aromatic hydrocarbon fractions; and 5) state recommended default values for soil properties (fraction of organic carbon (foc), dry soil bulk density (ρ_b), water filled soil porosity (Θ_w), air filled soil porosity (Θ_a), total soil porosity (n), soil particle density (ρ_s) and inverse of the mean concentration at the center of the source (Q/C)) and Summers default dilution factor as listed below. Where applicable, a risk-based standard was calculated for both carcinogenic and noncarcinogenic health effects and the lower of the two values was selected as the final standard. Soil standards shall contain 2 significant digits.

Parameter	**State-Recommended Default Value**
fraction of organic carbon (f_{oc})	0.006 g/g
dry soil bulk density (ρ_b)	1.7g/cm^3
water filled soil porosity (Θ_w)	0.21 L_{water}/L_{soil}
air filled soil porosity (Θ_a)	0.15 L_{air}/L_{soil}
total soil porosity (n)	0.36 L_{pore}/L_{soil}
soil particle density (ρ_s)	2.65 g/cm^3
Summers dilution factor (DF)	20
inverse of the mean concentration at the center of the source (Q/C)	76.39 g/m^2-s per kg/m^3 (0.5 acre) (Houston)

Screening Standards for constituents not listed in Table 1 and MO-1 RS for constituents not listed in Table 2 and site-specific MO-2 RS and site-specific MO-3 RS shall be based on: 1) current toxicity values selected in accordance with the hierarchy defined in Section 2.4 and Appendix D Table H-4 for the TPH components; 2) *EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites* calculator physical/chemical properties (TPHCWG physical/chemical properties for TPH fractions); 3) a Target Cancer Risk (TR) and Target Hazard Quotient (THQ) selected in accordance with Section 2.5 and this appendix; 4) site-specific input values were available and appropriate for the option being implemented; in the absence of site-specific data, state recommended default values for shall be used; and 5) the equations presented in this appendix for $Soil_{GW3}$ and the most current version of the *EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites* User's Guide/Calculator equations for $Soil_{ni}$, $Soil_{i}$, $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{sat}$. Refer to Section A4.0 for definitions of the equation parameters and

the default input values. For a risk-based standard ($Soil_{ssni}$, $Soil_{ssi}$ $Soil_{ni}$, $Soil_i$), where applicable, a standard shall be calculated for both carcinogenic and noncarcinogenic health effects and the lower of the two values shall serve as the standard.

A1.1 Non-industrial (Residential) Risk-Based Standard – ($Soil_{SSni}$, $Soil_{ni}$)

A1.1.1 Carcinogenic Health Effects

$Soil_{SSni}$ or $Soil_{ni}$ (mg/kg) =

$$\frac{1}{\frac{1}{\text{Ingestion}}+\frac{1}{\text{Inhalation}}+\frac{1}{\text{Dermal}}}$$

Ingestion (mg/kg) =

$$=\frac{TR\times AT_r\left(\frac{365\text{ days}}{\text{year}}\times LT\,(70\text{ years})\right)}{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}\times IFS_{adj}\left(\frac{36750\text{ mg-Year}}{Kg\text{-}day}\right)\times\left(\frac{10^{-6}Kg}{mg}\right)}$$

where:

$$IFS_{adj}\left(\frac{36750\text{ mg-Year}}{Kg\text{-}day}\right)=\frac{EF_{ressc}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_c\,(6\text{ years})\times IRS_c\left(\frac{200\text{ mg}}{\text{day}}\right)}{BW_c\,(15\text{ Kg})}+\frac{EF_{ressa}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_r\text{-}ED_c\,(20\text{ years})\times IRS_a\left(\frac{100\text{ mg}}{\text{day}}\right)}{BW_a\,(80\text{ Kg})}$$

Inhalation (mg/kg) =

$$\frac{TR \times AT_r \left(\frac{365\ \text{days}}{\text{year}} \times LT\,(70\ \text{years})\right)}{IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1000\ \mu g}{mg}\right) \times EF_r \left(\frac{350\ \text{days}}{\text{year}}\right) \times \left(\frac{1}{VF_s\left(\frac{m^3}{Kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{Kg}\right)}\right) \times ED_r\,(26\ \text{years}) \times ET_{rs}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right)}$$

Dermal (mg/kg) =

$$\frac{TR \times AT_r \left(\frac{365\ \text{days}}{\text{year}} \times LT\,(70\ \text{years})\right)}{\left(\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\right) \times DFS_{adj}\left(\frac{112266\ \text{mg-Year}}{Kg\text{-}day}\right) \times ABS_d \times \left(\frac{10^{-6}\,Kg}{mg}\right)}$$

where:

$$DFS_{adj}\left(\frac{112266\ \text{mg-Year}}{Kg\text{-}day}\right) = \frac{EF_{ressc}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_c\,(6\ \text{years}) \times SA_c\left(\frac{2690\ cm^2}{\text{day}}\right) \times AF_c\left(\frac{0.2\ mg}{cm^2}\right)}{BW_c\,(15\ Kg)} + \frac{EF_{ressa}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_r\text{-}ED_c\,(20\ \text{years}) \times SA_a\left(\frac{6032\ cm^2}{\text{day}}\right) \times AF_a\left(\frac{0.07\ mg}{cm^2}\right)}{BW_a\,(80\ Kg)}$$

A1.1.2 Mutagenic Health Effects

$Soil_{SSni}$ or $Soil_{ni}$ (mg/kg) =

$$\frac{1}{\frac{1}{\text{Ingestion}}+\frac{1}{\text{Inhalation}}+\frac{1}{\text{Dermal}}}$$

Ingestion (mg/kg) =

$$\frac{TR \times AT_r\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}{CSF_o\left(\frac{\text{mg}}{\text{Kg-day}}\right)^{-1} \times IFSM_{adj}\left(\frac{166833.33\ \text{mg-Year}}{\text{Kg-day}}\right) \times \left(\frac{10^{-6}\text{Kg}}{\text{mg}}\right)}$$

where:

$$IFSM_{adj}\left(\frac{166833.33\ \text{mg-Year}}{\text{Kg-day}}\right) = \frac{EF_{ressc\ 0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{0\text{-}2}\ (\text{yr}) \times IRS_c\left(\frac{200\ \text{mg}}{\text{day}}\right) \times 10}{BW_c\ (15\ \text{Kg})} + \frac{EF_{ressc\ 2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{2\text{-}6}\ (\text{yr}) \times IRS_c\left(\frac{200\ \text{mg}}{\text{day}}\right) \times 3}{BW_c\ (15\ \text{Kg})} +$$

$$\frac{EF_{ressa\ 6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{6\text{-}16}\ (\text{yr}) \times IRS_a\left(\frac{100\ \text{mg}}{\text{day}}\right) \times 3}{BW_a\ (80\ \text{Kg})} + \frac{EF_{ressa\ 16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{16\text{-}26}\ (\text{yr}) \times IRS_a\left(\frac{100\ \text{mg}}{\text{day}}\right) \times 1}{BW_a\ (80\ \text{Kg})}$$

Inhalation (mg/kg) =

$$\frac{TR \times AT_r \left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}{ET_{rs}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times \left(\begin{array}{l} \left(EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{0\text{-}2}\ (\text{yrs}) \times IUR\left(\mu g/m^3\right)^{-1} \times 10\right) + \\ \left(EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{2\text{-}6}\ (\text{yrs}) \times IUR\left(\mu g/m^3\right)^{-1} \times 3\right) + \\ \left(EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{6\text{-}16}\ (\text{yrs}) \times IUR\left(\mu g/m^3\right)^{-1} \times 3\right) + \\ \left(EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{16\text{-}26}\ (\text{yrs}) \times IUR\left(\mu g/m^3\right)^{-1} \times 1\right) \end{array}\right) \times \left(\frac{1}{VF_s\left(\frac{m^3}{Kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{Kg}\right)}\right)}$$

Dermal (mg/kg) =

$$\frac{TR \times AT_r \left(\frac{365\ \text{days}}{\text{year}} \times LT\,(70\ \text{years})\right)}{\left(\frac{CSF_o \left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\right) \times DFSM_{adj}\left(\frac{475598.67\ mg\text{-}Year}{Kg\text{-}day}\right) \times ABS_d \times \left(\frac{10^{-6} Kg}{mg}\right)}$$

where:

$$DFSM_{adj}\left(\frac{475598.67\ mg\text{-}Year}{Kg\text{-}day}\right) = \frac{EF_{ressc\ 0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{0\text{-}2}\,(yr) \times AF_c\left(\frac{0.2\ mg}{cm^2}\right) \times SA_c\left(\frac{2690\ cm^2}{day}\right) \times 10}{BW_c\,(15\ Kg)} + \frac{EF_{ressc\ 2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{2\text{-}6}\,(yr) \times AF_c\left(\frac{0.2\ mg}{cm^2}\right) \times SA_c\left(\frac{2690\ cm^2}{day}\right) \times 3}{BW_c\,(15\ Kg)} +$$

$$\frac{EF_{ressa\ 6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{6\text{-}16}\,(yr) \times AF_a\left(\frac{0.07\ mg}{cm^2}\right) \times SA_a\left(\frac{6032\ cm^2}{day}\right) \times 3}{BW_a\,(80\ Kg)} + \frac{EF_{ressa\ 16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{16\text{-}26}\,(yr) \times AF_a\left(\frac{0.07\ mg}{cm^2}\right) \times SA_a\left(\frac{6032\ cm^2}{day}\right) \times 1}{BW_a\,(80\ Kg)}$$

A1.1.3 Vinyl Chloride Carcinogenic Health Effects

$Soil_{SSni}$ or $Soil_{ni}$ (mg/kg) =

$$\frac{1}{\frac{1}{\text{Ingestion}} + \frac{1}{\text{Inhalation}} + \frac{1}{\text{Dermal}}}$$

Ingestion (mg/kg) =

$$\frac{TR}{\left(\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}\times IFS_{adj}\left(\frac{36750\ mg}{kg}\right)\times\frac{10^{-6}Kg}{1\ mg}}{AT_r\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)}\right)+\left(\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}\times IRS_c\left(\frac{200\ mg}{day}\right)\times\frac{10^{-6}Kg}{1\ mg}}{BW_c\ (15\ kg)}\right)}$$

where:

$$IFS_{adj}\left(\frac{36750\ mg}{Kg}\right)=\frac{EF_{ressc}\left(\frac{350\ days}{year}\right)\times ED_c\ (6\ years)\times IRS_c\left(\frac{200\ mg}{day}\right)}{BW_c\ (15\ Kg)}+\frac{EF_{ressa}\left(\frac{350\ days}{year}\right)\times ED_r\text{-}ED_c\ (20\ years)\times IRS_a\left(\frac{100\ mg}{day}\right)}{BW_a\ (80\ Kg)}$$

Inhalation (mg/kg) =

$$\frac{TR}{\left(\frac{IUR\left(\mu g/m^3\right)^{-1} \times EF_r\left(\frac{350\ days}{year}\right) \times ED\left(26\ years\right) \times ET_{rs}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{AT_r\left(\frac{365\ days}{year} \times LT\left(70\ years\right)\right) \times VF_s\left(\frac{m^3}{kg}\right)}\right) + \left(\frac{IUR\left(\mu g/m^3\right)^{-1}}{VF_s\left(\frac{m^3}{kg}\right)} \times \left(\frac{1000\ \mu g}{mg}\right)\right)}$$

Dermal (mg/kg) =

$$\frac{TR}{\left(\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\times DFS_{adj}\left(\frac{112266\ mg}{kg}\right)\times ABS_d\times\frac{10^{-6}Kg}{1\ mg}}{AT_r\left(\frac{365\ days}{year}\times LT\,(70\ years)\right)}\right)+\left(\frac{\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\times SA_c\left(\frac{2690\ cm^2}{day}\right)\times AF_c\left(\frac{0.2\ mg}{cm^2}\right)\times ABS\times\frac{10^{-6}Kg}{1\ mg}}{BW_c\,(15\ kg)}\right)}$$

where:

$$DFS_{adj}\left(\frac{112266\ mg}{Kg}\right)=\frac{EF_{ressc}\left(\frac{350\ days}{year}\right)\times ED_c\,(6\ years)\times SA_c\left(\frac{2690\ cm^2}{day}\right)\times AF_c\left(\frac{0.2\ mg}{cm^2}\right)}{BW_c\,(15\ Kg)}+\frac{EF_{ressa}\left(\frac{350\ days}{year}\right)\times ED_r\text{-}ED_c\,(20\ years)\times SA_a\left(\frac{6032\ cm^2}{day}\right)\times AF_a\left(\frac{0.07\ mg}{cm^2}\right)}{BW_a\,(80\ Kg)}$$

A1.1.4 Trichloroethylene Mutagenic and Carcinogenic Health Effects

$$\text{Soil}_{SSni} \text{ or } \text{Soil}_{ni} \text{ (mg/kg)} = \frac{1}{\frac{1}{\text{Ingestion}} + \frac{1}{\text{Inhalation}} + \frac{1}{\text{Dermal}}}$$

$$\text{Ingestion (mg/kg)} = \frac{TR \times AT_{ress}\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}{CSF_o\left(\frac{\text{mg}}{\text{Kg-day}}\right)^{-1} \times \left(\frac{10^{-6}\text{Kg}}{\text{mg}}\right) \times \left(\left(CAF_o\ (0.804) \times IFS_{res\text{-}adj}\left(\frac{37650\ \text{mg}}{\text{Kg}}\right)\right) + \left(MAF_o\ (0.202) \times IFSM_{res\text{-}adj}\left(\frac{166833.33\ \text{mg}}{\text{Kg}}\right)\right)\right)}$$

where:

$$IFS_{res\text{-}adj}\left(\frac{36750\ \text{mg}}{\text{Kg}}\right) = \frac{ED_{ressc}\ (6\ \text{years}) \times EF_{ressc}\left(\frac{350\ \text{days}}{\text{year}}\right) \times IRS_{ressc}\left(\frac{200\ \text{mg}}{\text{day}}\right)}{BW_{ressc}\ (15\ \text{Kg})} + \frac{ED_{ress}\ (26\ \text{years}) - ED_{ressc}\ (6\ \text{years}) \times EF_{ressa}\left(\frac{350\ \text{days}}{\text{year}}\right) \times IRS_{ressa}\left(\frac{100\ \text{mg}}{\text{day}}\right)}{BW_{ressa}\ (80\ \text{Kg})}$$

where:

$$IFSM_{res\text{-}adj\text{-}}\left(\frac{166833.33\ \text{mg}}{\text{Kg}}\right) = \frac{ED_{0\text{-}2}\ (2\,\text{years}) \times EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times IRS_{0\text{-}2}\left(\frac{200\ \text{mg}}{\text{day}}\right) \times 10}{BW_{0\text{-}2}\ (15\ \text{Kg})} + \frac{ED_{2\text{-}6}\ (4\,\text{years}) \times EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times IRS_{2\text{-}6}\left(\frac{200\ \text{mg}}{\text{day}}\right) \times 3}{BW_{2\text{-}6}\ (15\ \text{Kg})} + \frac{ED_{6\text{-}16}\ (10\,\text{years}) \times EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times IRS_{6\text{-}16}\left(\frac{100\ \text{mg}}{\text{day}}\right) \times 3}{BW_{6\text{-}16}\ (80\ \text{Kg})} + \frac{ED_{16\text{-}26}\ (10\ \text{years}) \times EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times IRS_{16\text{-}26}\left(\frac{100\ \text{mg}}{\text{day}}\right) \times 1}{BW_{16\text{-}26}\ (80\ \text{Kg})}$$

Inhalation (mg/kg) =

$$\frac{TR \times AT_{ress}\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}{IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1}{VF_s\left(\frac{m^3}{Kg}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{Kg}\right)}\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \left(\left(CAF_i\ (0.756) \times EF_{ress}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{ress}\ (26\ \text{years}) \times ET_{ress}\left(\frac{24\ \text{hours}}{\text{day}}\right)\right) + \left(\left(ED_{0\text{-}2}\ (2\ \text{years}) \times EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{0\text{-}2}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times MAF_i\ (0.244) \times 10\right) + \left(ED_{2\text{-}6}\ (4\ \text{years}) \times EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{2\text{-}6}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times MAF_i\ (0.244) \times 3\right) + \left(ED_{6\text{-}16}\ (10\ \text{years}) \times EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{6\text{-}16}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times MAF_i\ (0.244) \times 3\right) + \left(ED_{16\text{-}26}\ (10\ \text{years}) \times EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{16\text{-}26}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times MAF_i\ (0.244) \times 1\right)\right)\right)}$$

Dermal (mg/kg) =

$$\frac{TR \times AT_{ress}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}{\left(\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\right) \times \left(\frac{10^{-6} Kg}{mg}\right) \times \left(\left(CAF_o\ (0.804) \times DFS_{res\text{-}adj}\left(\frac{112266\ mg}{Kg}\right) \times ABS_d\right) + \left(MAF_o\ (0.202) \times DFSM_{res\text{-}adj}\left(\frac{475598.67\ mg}{Kg}\right) \times ABS_d\right)\right)}$$

where:

$$DFS_{res\text{-}adj}\left(\frac{112266\ mg}{Kg}\right) = \frac{ED_{ressc}\ (6\ years) \times EF_{ressc}\left(\frac{350\ days}{year}\right) \times SA_{ressc}\left(\frac{2690\ cm^2}{day}\right) \times AF_{ressc}\left(\frac{0.2\ mg}{cm^2}\right)}{BW_{ressc}\ (15\ Kg)} +$$

$$\frac{ED_{ress}\ (26\ years) - ED_{ressc}\ (6\ years) \times EF_{ressa}\left(\frac{350\ days}{year}\right) \times SA_{ressa}\left(\frac{6032\ cm^2}{day}\right) \times AF_{ressa}\left(\frac{0.07\ mg}{cm^2}\right)}{BW_{ressa}\ (80\ Kg)}$$

where:

$$DFSM_{res\text{-}adj}\left(\frac{475598.67\ mg}{Kg}\right) = \frac{ED_{0\text{-}2}\ (2\ years) \times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times AF_{0\text{-}2}\left(\frac{0.2\ mg}{cm^2}\right) \times SA_{0\text{-}2}\left(\frac{2690\ cm^2}{day}\right) \times 10}{BW_{0\text{-}2}\ (15\ Kg)} +$$

$$\frac{ED_{2\text{-}6}\ (4\ years) \times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times AF_{2\text{-}6}\left(\frac{0.2\ mg}{cm^2}\right) \times SA_{2\text{-}6}\left(\frac{2690\ cm^2}{day}\right) \times 3}{BW_{2\text{-}6}\ (15\ Kg)} +$$

$$\frac{ED_{6\text{-}16}\ (10\ years) \times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times AF_{6\text{-}16}\left(\frac{0.07\ mg}{cm^2}\right) \times SA_{6\text{-}16}\left(\frac{6032\ cm^2}{day}\right) \times 3}{BW_{6\text{-}16}\ (80\ Kg)} +$$

$$\frac{ED_{16\text{-}26}\ (10\ years) \times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times AF_{16\text{-}26}\left(\frac{0.07\ mg}{cm^2}\right) \times SA_{16\text{-}26}\left(\frac{6032\ cm^2}{day}\right) \times 1}{BW_{16\text{-}26}\ (80\ Kg)}$$

$$CAF_o(0.804) = \frac{CSF_o\left(\frac{3.7\times10^{-2}\,mg}{Kg\text{-}day}\right)^{-1}\ \text{NHL+Liver oral slope factor}}{CSF_o\left(\frac{4.6\times10^{-2}\,mg}{Kg\text{-}day}\right)^{-1}\ \text{Adult-based oral slope factor}}$$

$$MAF_o(0.202) = \frac{CSF_o\left(\frac{9.3\times10^{-3}\,mg}{Kg\text{-}day}\right)^{-1}\ \text{Kidney oral slope factor}}{CSF_o\left(\frac{4.6\times10^{-2}\,mg}{Kg\text{-}day}\right)^{-1}\ \text{Adult-based oral slope factor}}$$

$$CAF_i(0.756) = \frac{IUR\left(3.1\times10^{-6}\,\mu g/m^3\right)^{-1}\ \text{NHL+Liver unit risk estimate}}{IUR\left(4.1\times10^{-6}\,\mu g/m^3\right)^{-1}\ \text{Adult-based unit risk estimate}}$$

$$MAF_i(0.244) = \frac{IUR\left(1\times10^{-6}\,\mu g/m^3\right)^{-1}\ \text{Kidney unit risk estimate}}{IUR\left(4.1\times10^{-6}\,\mu g/m^3\right)^{-1}\ \text{Adult-based unit risk estimate}}$$

A1.1.5 Noncarcinogenic Health Effects

$Soil_{SSni}$ or $Soil_{ni}$ (mg/kg) =

$$\frac{1}{\frac{1}{\text{Ingestion}}+\frac{1}{\text{Inhalation}}+\frac{1}{\text{Dermal}}}$$

Ingestion (mg/kg) =

$$\frac{THQ \times AT_r\left(\frac{365\ \text{days}}{\text{year}} \times ED_c\ (6\ \text{years})\right) \times BW_c\ (15\ \text{Kg})}{EF_r\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_c\ (6\ \text{year}) \times \frac{1}{RfD_o\left(\frac{\text{mg}}{\text{Kg-day}}\right)} \times IRS_c\left(\frac{200\ \text{mg}}{\text{day}}\right) \times \frac{10^{-6}\text{Kg}}{1\ \text{mg}}}$$

Inhalation (mg/kg) =

$$\frac{THQ \times AT_r\left(\frac{365\ \text{days}}{\text{year}} \times ED_c\ (6\ \text{years})\right)}{EF_r\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_c\ (6\ \text{year}) \times ET_{rs}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \frac{1}{RfC\left(\text{mg}/\text{m}^3\right)} \times \left(\frac{1}{VF_s\left(\frac{\text{m}^3}{\text{Kg}}\right)} + \frac{1}{PEF_w\left(\frac{\text{m}^3}{\text{Kg}}\right)}\right)}$$

Dermal (mg/kg) =

$$\frac{THQ \times AT_r \left(\frac{365\ days}{year} \times ED_c\ (6\ years)\right) \times BW_c\ (15\ Kg)}{EF_r \left(\frac{350\ days}{year}\right) \times ED_c\ (6\ year) \times \frac{1}{\left(RfD_o \left(\frac{mg}{Kg\text{-}day}\right) \times GIABS\right)} \times SA_c \left(\frac{2690\ cm^2}{day}\right) \times AF_c \left(\frac{0.2\ mg}{cm^2}\right) \times ABS_d \times \frac{10^{-6} Kg}{1 mg}}$$

A1.1.6 Supporting Equations

Child:

$$ED_c\,(6\text{ years}) = ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})$$

$$BW_c\,(15\text{ kg}) = \frac{BW_{0\text{-}2}\,(15\text{ kg}) \times ED_{0\text{-}2}\,(2\text{ years}) + BW_{2\text{-}6}\,(15\text{ kg}) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$EF_c\left(\frac{350\text{ days}}{\text{year}}\right) = \frac{EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$AF_c\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right) = \frac{AF_{0\text{-}2}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + AF_{2\text{-}6}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$SA_c\left(\frac{2690\text{ cm}^2}{\text{day}}\right) = \frac{SA_{0\text{-}2}\left(\frac{2690\text{ cm}^2}{\text{day}}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + SA_{2\text{-}6}\left(\frac{2690\text{ cm}^2}{\text{day}}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

$$IRS_c\left(\frac{200\text{ mg}}{\text{day}}\right) = \frac{IRS_{0\text{-}2}\left(\frac{200\text{ mg}}{\text{day}}\right) \times ED_{0\text{-}2}\,(2\text{ years}) + IRS_{2\text{-}6}\left(\frac{200\text{ mg}}{\text{day}}\right) \times ED_{2\text{-}6}\,(4\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years})}$$

Adult:

$$ED_a\,(20\text{ years}) = ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})$$

$$BW_a\,(80\text{ kg}) = \frac{BW_{6\text{-}16}\,(80\text{ kg}) \times ED_{6\text{-}16}\,(10\text{ years}) + BW_{16\text{-}26}\,(80\text{ kg}) \times ED_{16\text{-}26}\,(10\text{ years})}{ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})}$$

$$EF_a\left(\frac{350\text{ days}}{\text{year}}\right) = \frac{EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{6\text{-}16}\,(10\text{ years}) + EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right) \times ED_{16\text{-}26}\,(10\text{ years})}{ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})}$$

$$AF_a\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right) = \frac{AF_{6\text{-}16}\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right) \times ED_{6\text{-}16}\,(10\text{ years}) + AF_{16\text{-}26}\left(\frac{0.07\text{ mg}}{\text{cm}^2}\right) \times ED_{16\text{-}26}\,(10\text{ years})}{ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})}$$

$$SA_a\left(\frac{6032\text{ cm}^2}{\text{day}}\right) = \frac{SA_{6\text{-}16}\left(\frac{6032\text{ cm}^2}{\text{day}}\right) \times ED_{6\text{-}16}\,(10\text{ years}) + SA_{16\text{-}26}\left(\frac{6032\text{ cm}^2}{\text{day}}\right) \times ED_{16\text{-}26}\,(10\text{ years})}{ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})}$$

$$IRS_a\left(\frac{100\text{ mg}}{\text{day}}\right) = \frac{IRS_{6\text{-}16}\left(\frac{100\text{ mg}}{\text{day}}\right) \times ED_{6\text{-}16}\,(10\text{ years}) + IRS_{16\text{-}26}\left(\frac{100\text{ mg}}{\text{day}}\right) \times ED_{16\text{-}26}\,(10\text{ years})}{ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})}$$

Age-adjusted:

$$ED_r\,(26\text{ years}) = ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years}) + ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})$$

$$EF_r\left(\frac{350\text{ days}}{\text{year}}\right) = \frac{EF_{0\text{-}2}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{0\text{-}2}\,(2\text{ years}) + EF_{2\text{-}6}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{2\text{-}6}\,(4\text{ years}) + EF_{6\text{-}16}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{6\text{-}16}\,(10\text{ years}) + EF_{16\text{-}26}\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_{16\text{-}26}\,(10\text{ years})}{ED_{0\text{-}2}\,(2\text{ years}) + ED_{2\text{-}6}\,(4\text{ years}) + ED_{6\text{-}16}\,(10\text{ years}) + ED_{16\text{-}26}\,(10\text{ years})\;ET_{ress}\left(\frac{24\text{ hour}}{\text{day}}\right)}$$

Trichloroethylene:

$$CAF_o\,(0.804) = \frac{CSF_o\left(\frac{3.7\times10^{-2}\text{mg}}{\text{Kg-day}}\right)^{-1}\text{ NHL+Liver oral slope factor}}{CSF_o\left(\frac{4.6\times10^{-2}\text{mg}}{\text{Kg-day}}\right)^{-1}\text{ Adult-based oral slope factor}}\qquad MAF_o\,(0.202) = \frac{CSF_o\left(\frac{9.3\times10^{-3}\text{mg}}{\text{Kg-day}}\right)^{-1}\text{ Kidney oral slope factor}}{CSF_o\left(\frac{4.6\times10^{-2}\text{mg}}{\text{Kg-day}}\right)^{-1}\text{ Adult-based oral slope factor}}$$

$$CAF_i\,(0.756) = \frac{IUR\left(3.1\times10^{-6}\,\mu g/m^3\right)^{-1}\text{ NHL+Liver unit risk estimate}}{IUR\left(4.1\times10^{-6}\,\mu g/m^3\right)^{-1}\text{ Adult-based unit risk estimate}}\qquad MAF_i\,(0.244) = \frac{IUR\left(1\times10^{-6}\,\mu g/m^3\right)^{-1}\text{ Kidney unit risk estimate}}{IUR\left(4.1\times10^{-6}\,\mu g/m^3\right)^{-1}\text{ Adult-based unit risk estimate}}$$

A1.2 Industrial/Commercial (Composite Worker) Risk-Based Standard – ($Soil_{SSi}$, $Soil_i$)

A1.2.1 Carcinogenic Health Effects

$$\text{Soil}_{SSi} \text{ or } \text{Soil}_i \text{ (mg/kg)} = \frac{1}{\frac{1}{\text{Ingestion}} + \frac{1}{\text{Inhalation}} + \frac{1}{\text{Dermal}}}$$

$$\text{Ingestion (mg/kg)} = \frac{TR \times AT_{ow}\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right) \times BW_{ow}\ (80\ \text{Kg})}{EF_{iw}\left(250\ \frac{\text{days}}{\text{year}}\right) \times ED_{ow}\ (25\ \text{years}) \times CSF_o\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1} \times IR_{ow}\left(100\ \frac{\text{mg}}{\text{day}}\right) \times \left(\frac{10^{-6}\ \text{Kg}}{1\ \text{mg}}\right)}$$

$$\text{Inhalation (mg/kg)} = \frac{TR \times AT_{ow}\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}{EF_{iw}\left(250\ \frac{\text{days}}{\text{year}}\right) \times ED_{ow}\ (25\ \text{years}) \times ET_{ws}\left(\frac{8\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times IUR\left(\mu g/m^3\right)^{-1} \times \left(\frac{1000\ \mu g}{\text{mg}}\right) \times \left(\frac{1}{VF_s\left(\frac{m^3}{\text{kg}}\right)} + \frac{1}{PEF_w\left(\frac{m^3}{\text{kg}}\right)}\right)}$$

Dermal (mg/kg) =

$$\frac{TR \times AT_{ow}\left(\frac{365\ \text{days}}{\text{year}} \times LT\,(70\ \text{years})\right) \times BW_{ow}\,(80\ \text{Kg})}{EF_{iw}\left(250\ \frac{\text{days}}{\text{year}}\right) \times ED_{ow}\,(25\ \text{years}) \times \left(\frac{CSF_o\left(\frac{\text{mg}}{\text{kg-day}}\right)^{-1}}{GIABS}\right) \times SA_{ow}\left(\frac{3470\ \text{cm}^2}{\text{day}}\right) \times AF_{ow}\left(\frac{0.12\ \text{mg}}{\text{cm}^2}\right) \times ABS_d \times \left(\frac{10^{-6}\ \text{Kg}}{1\ \text{mg}}\right)}$$

A1.2.2 Noncarcinogenic Health Effects

$Soil_{SSi}$ or $Soil_i$ (mg/kg) =

$$\frac{1}{\frac{1}{\text{Ingestion}}+\frac{1}{\text{Inhalation}}+\frac{1}{\text{Dermal}}}$$

Ingestion (mg/kg) =

$$\frac{THQ \times AT_{ow}\left(\frac{365\ \text{days}}{\text{year}} \times ED_{ow}\ (25\ \text{years})\right) \times BW_{ow}\ (80\ \text{Kg})}{EF_{iw}\left(250\ \frac{\text{days}}{\text{year}}\right) \times ED_{ow}\ (25\ \text{years}) \times \frac{1}{RfD_o\left(\frac{\text{mg}}{\text{kg-day}}\right)} \times IR_{ow}\left(100\ \frac{\text{mg}}{\text{day}}\right) \times \left(\frac{10^{-6}\ \text{Kg}}{1\ \text{mg}}\right)}$$

Inhalation (mg/kg) =

$$\frac{THQ \times AT_{ow}\left(\frac{365\ \text{days}}{\text{year}} \times ED_{ow}\ (25\ \text{years})\right)}{EF_{iw}\left(250\ \frac{\text{days}}{\text{year}}\right) \times ED_{ow}\ (25\ \text{years}) \times ET_{ws}\left(\frac{8\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \frac{1}{RfC\left(\text{mg}/\text{m}^3\right)} \times \left(\frac{1}{VF_s\left(\frac{\text{m}^3}{\text{kg}}\right)} + \frac{1}{PEF_w\left(\frac{\text{m}^3}{\text{kg}}\right)}\right)}$$

Dermal (mg/kg) =

$$= \frac{THQ \times AT_{ow}\left(\frac{365\ days}{year} \times ED_{ow}\ (25\ years)\right) \times BW_{ow}\ (80\ Kg)}{EF_{iw}\left(250\ \frac{days}{year}\right) \times ED_{ow}\ (25\ years) \times \left(\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right) \times GIABS}\right) \times SA_{ow}\left(\frac{3470\ cm^2}{day}\right) \times AF_{ow}\left(\frac{0.12\ mg}{cm^2}\right) \times ABS_d \times \left(\frac{10^{-6}\ Kg}{1\ mg}\right)}$$

A1.3 Volatilization Factor (VF) for $Soil_{ssni}$, $Soil_{ni}$, $Soil_{ssi}$, $Soil_i$

The soil-to-air VF is used to define the relationship between the concentration of the constituent in soil and the flux of the volatilized constituent to air. VF is only calculated for volatile organic compounds (VOC). A VOC is generally defined as a chemical having a Henry's Law constant greater than or equal to 1 x 10^{-5} atm-m^3/mole and a molecular weight less than 200 g/mole or a vapor pressure greater than or equal to 1 mm Hg. Exceptions are: mercury (elemental), pyrene, dibromochloromethane and 1,2-dibromo-3-chloropropane. Refer to Section A4.0 for symbol definitions and input values.

The basic principle of the model is applicable only if the soil constituent concentration is at or below saturation. Saturation is the soil constituent concentration ($Soil_{sat}$) at which the adsorptive limits of the soil particles and the solubility limits of the available soil moisture have been reached. Above saturation, pure liquid-phase constituent may be present in the soil. $Soil_{sat}$ concentrations represent an upper limit to the applicability of the VF model because a basic principle of the model (Henry's Law) does not apply where constituents are present in free phrase. Therefore, above saturation, the risk-based soil RS based on the VF model cannot be accurately calculated based on volatilization. Because of this limitation, the risk-based RS calculated using the VF must be compared with the $Soil_{sat}$. If the $Soil_{ssni}$, $Soil_{ni}$, $Soil_{ssi}$, or $Soil_i$ is greater than $Soil_{sat}$, then the risk-based RS is set equal to $Soil_{sat}$. $Soil_{sat}$ should be calculated using the same soil characteristics (bulk density, average water content, organic carbon content, etc.) used to calculate VF (*Soil Screening Guidance*, EPA 1996). The SS, MO-1 RS, and Appendix G MO-2 RS are based on a Q/C for a 0.5 acre soil source size and Houston as the climatic zone.

Volatilization Factor:

$$VF = \frac{\frac{Q}{C_w} \times \left(3.14 \times D_A \times T\right)^{\frac{1}{2}} \times 10^{-4} \left(m^2/cm^2\right)}{2 \times \rho_b \times D_A}$$

where

$$\frac{Q}{C_w} = A \times \exp\left[\frac{\left(\ln A_s - B\right)^2}{C}\right] \text{ and}$$

$$D_A = \frac{\left[\left(\theta_a^{10/3} \times D_{ia} \times H' + \theta_w^{10/3} \times D_{iw}\right) / n^2\right]}{\rho_b \times K_d + \theta_w + \theta_a \times H'}$$

Diffusivity in water:

$$D_{iw}\left(\frac{cm^2}{s}\right)=0.0001518\times\left(\frac{T\,^{o}C+273.16}{298.16}\right)\times\left(\frac{MW\left(\frac{g}{mol}\right)}{\rho\left(\frac{g}{cm^3}\right)}\right)^{-0.6}$$

where

T typically = $25^{o}C$

If density is not available,

$$D_{iw}\left(\frac{cm^2}{s}\right)=0.000222\times(MW)^{-\left(\frac{2}{3}\right)}$$

Diffusivity in air:

$$D_{ia}\left(\frac{cm^2}{s}\right)=\frac{0.00229\times\left(T\,^{o}C+273.16\right)^{1.5}\times\sqrt{0.034+\left(\frac{1}{MW\left(\frac{g}{mol}\right)}\right)}\times MW_{cor}}{\left(\left(\frac{MW\left(\frac{g}{mol}\right)}{2.5\times\rho\left(\frac{g}{cm^3}\right)}\right)^{0.333}+1.8\right)^{2}}$$

where

T typically = $25^{o}C$

$MW_{cor}=\left(1-0.000015\times MW^2\right)$ If MW_{cor} is less than 0.4, then MW_{cor} is set to 0.4.

If density is not available,

$$D_{ia}\left(\frac{cm^2}{s}\right)=1.9\times\left(MW\left(\frac{g}{mol}\right)^{-\left(\frac{2}{3}\right)}\right)$$ except for dioxins use, $$D_{ia}\left(\frac{cm^2}{s}\right)=\left(\frac{154}{MW\left(\frac{g}{mol}\right)}\right)^{0.5}\times 0.068$$

A1.4 Particulate Emission Factor (PEF) for $Soil_{ssni}$, $Soil_{ni}$, $Soil_{ssi}$, $Soil_{i}$

$$PEF_w = \frac{Q}{C_w} \times \frac{3{,}600}{0.036 \times (1-V) \times (U_m/U_t)^3 \times F(x)}$$

where

$$\frac{Q}{C_w} = A \times \exp\left[\frac{(\ln A_s - B)^2}{C}\right]$$

The SS, MO-1 RS, and Appendix G MO-2 RS are based on a Q/C for a 0.5 soil source size and Houston as the climatic zone. Refer to Section A4.0 for symbol definitions and input values.

A1.5 Soil to Groundwater Pathway ($Soil_{SSGW}$, $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3}$)

A1.5.1 Method 1 Partitioning Equation

The soil/water partition equation given below shall be used to relate the constituent concentration adsorbed to the soil organic carbon to the soil leachate concentration in the zone of contamination.

The GW_1 shall serve as the C_w for $Soil_{GW1}$ and $Soil_{GW2}$. The GW_{3NDW} or GW_{3DW} shall serve as the C_w for $Soil_{GW3NDW}$ and $Soil_{GW3DW}$, respectively. Refer to Table 3 for the GW_1, GW_{3NDW}, GW_{3DW}. For constituents not listed in Table 3, refer to Section A2.0 for guidance on determining the groundwater standard.

A Summers dilution factor (DF) shall be used to yield the maximum theoretical constituent concentration in soil that is protective of the appropriate groundwater use. As chemicals present in the soil migrate, their concentrations are reduced by physical, chemical, and biochemical processes. To account for these processes, a dilution factor is used in the estimation of a soil concentration that is protective of groundwater. Under the SO and MO-1, a default Summers DF of 20 shall be used for the calculation of the $Soil_{GW}$. A DF of 20 is considered protective of groundwater resources for soil sources up to 0.5 acre in size (*Soil Screening Guidance: Technical Background Document*, EPA 1996). A site-specific Summers DF shall be used under MO-2 and MO-3. If the source area is less than or equal to 0.5 acre, the default Summers dilution factor of 20 may be used under MO-2 and MO-3.

$Soil_{GW}$ = (mg/kg): $$\frac{C_w(\rho_b x K_d + \theta_W + \theta_a x H')}{\rho_b} \text{ X DF}$$

where:

Parameter	Definition (units)	Input Value
$Soil_{GW}$	concentration adsorbed to soil organic carbon (mg/kg dry weight)	--
C_w	target soil leachate concentration (mg/L)	Groundwater RS
ρ_b	dry soil bulk density (g/cm^3)	1.7 [a]
θ_W	water filled soil porosity (L_{water}/L_{soil})	0.21[a]
K_d	soil-water partition coefficient = K_{oc} x f_{oc} (cm^3/g)	chemical-specific
K_{oc}	soil-organic carbon partition coefficient (cm^3/g)	chemical-specific
f_{oc}	fractional organic carbon in soil (g/g);	0.006 [a]
θ_a	air filled soil porosity (L_{air}/L_{soil})	n-θ_w

n	total soil porosity (L_{pore}/L_{soil})	$1 - \rho_b/\rho_s$
ρ_s	soil particle density (g/cm^3)	2.65 [a]
H'	Henry's Law Constant (dimensionless)	chemical-specific [b]
DF	Summers dilution factor (dimensionless)	20 [c]

[a]LDEQ default value.
[b]H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^{o}K); and T = absolute temperature of soil (^{o}K) [273 + ^{o}C (25°C)].
[c]For a source area < 0.5 acre.

A1.5.2 Method 2 Leachate Test ($Soil_{LS}$)

A leach test conducted in accordance with Appendix B may be used instead of the soil/water partition equation to relate concentrations of constituents adsorbed to soil organic carbon to soil leachate concentrations in the impacted zone. Refer to Table 3 for the GW_1, GW_2, and GW_3 RS. Refer to Section 4.2.3 of the main document for the default MO-1 Domenico dilution factors. Under SO and MO-1 a Summers default dilution factor of 20 is used. Refer to Sections A5.0 and A6.0 for the development of site-specific Summers and Domenico DF (MO-2 and MO-3), respectively.

The leachate test results shall be compared to the appropriate Soil Leachate Standard ($Soil_{LS}$) calculated as follows:

GW1: Groundwater Classification 1 Soil Leachate Standard ($Soil_{LSS}$ and $Soil_{LS1}$) = GW_1 x Summers DF

GW2: Groundwater Classification 2 Soil Leachate Standard ($Soil_{LS2}$) = GW_2 x Summers DF x Domenico DF2

GW3: Groundwater Classification 3 Soil Leachate Standard ($Soil_{LS3}$) = GW_3 x Summers DF x Domenico DF3

A1.6 Soil Saturation ($Soil_{sat}$)

The soil saturation concentration corresponds to the constituent concentration in soil at which the absorptive limits of the soil particles, the solubility limits of the soil pore water, and saturation of soil pore air have been reached. Above this concentration, the soil constituent may be present in free phase [i.e., nonaqueous phase liquids (NAPL)] for constituents that are liquid at ambient soil temperatures). $Soil_{sat}$ is only calculated for chemicals that are liquid at ambient soil temperatures. The $Soil_{sat}$ RS for the petroleum fractions were obtained from the literature, refer to Appendix D for additional information on addressing $Soil_{sat}$ for petroleum hydrocarbons. Refer to Section A4.0 for symbol definitions and input values.

Soilsat (mg/kg) =

$$\frac{S\left(\frac{mg}{L}\right)}{\rho_b\left(\frac{Kg}{L}\right)} \times \left(K_d\left(\frac{L}{Kg}\right) \times \rho_b\left(\frac{Kg}{L}\right) + \theta_w\left(\frac{L_{water}}{L_{soil}}\right) + H' \times \theta_a\left(\frac{L_{air}}{L_{soil}}\right)\right)$$

where

$$Kd = K_{oc}\left(\frac{L}{Kg}\right) \times f_{oc}\left(\frac{g}{g}\right),$$

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right) = n\left(\frac{L_{pore}}{L_{soil}}\right) - \theta_w\left(\frac{L_{water}}{L_{soil}}\right) \text{ and}$$

$$n = 1 - \left(\frac{\rho_b\left(\frac{Kg}{L}\right)}{\rho_s\left(\frac{Kg}{L}\right)}\right)$$

Soilsat (mg/kg) =

A2.0 Groundwater Standards

The Groundwater Standards include GW_{SS}, GW_1, GW_2, GW_{3DW}, GW_{3NDW}, $Water_{sol}$. The groundwater Screening Standards and RECAP Standards shall be identified or calculated in accordance with this appendix. Site-specific input values shall not be used in the calculation of GW_{ss}, GW_1, GW_2, or GW_3 Standards. A VOC is generally defined as a chemical having a Henry's Law constant greater than or equal to 1 x 10^{-5} atm-m^3/mole and a molecular weight less than 200 g/mole or a vapor pressure greater than or equal to 1 mm Hg. Groundwater standards shall contain 2 significant digits.

A2.1 Groundwater Classifications 1 and 2 (GW_{SS}, GW_1, GW_2)

The Screening Option GW_{ss} (Table 1), Management Option 1 GW_1 and GW_2 RECAP Standards (Table 3), and the Appendix G MO-2 GW_1 and GW_2 RECAP Standards (Table G-8) are based on the SDWA MCL; in the absence of an MCL, a risk-based value was calculated using: 1) the equations presented in this appendix; 2) toxicity values selected in accordance with the hierarchy defined in Section 2.4 and Appendix D Table H-4 for the TPH components; 3) a Target Cancer Risk (TR) and Target Hazard Quotient (THQ) as specified in Section 2.5; 4) *EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites* physical/chemical properties and TPHCWG physical/chemical properties for aliphatic and aromatic hydrocarbon fractions; and 5) if applicable, a risk-based standard (GW_1 and GW_2) was calculated for both carcinogenic and noncarcinogenic health effects (child receptor) and the lower of the two values was selected as the standard. Refer to Section A4.0 for definitions of the equation parameters and the default input values. For a COC not listed in Tables 1 and 3, the GW_{ss}, GW_1, and/or GW_2 shall be based on the MCL. In the absence of an MCL, a risk-based values shall be based on: 1) current toxicity values selected in accordance with the hierarchy defined in Section 2.4 and Appendix D Table H-4 for the TPH components; 2) a Target Cancer Risk (TR) and Target Hazard Quotient (THQ) selected in accordance with Section 2.5; 3) *EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites* calculator physical/chemical properties and TPHCWG physical/chemical properties for aliphatic and aromatic hydrocarbon fractions; and 4) the equations in this appendix or the most current version of the *EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites* User's Guide/Calculator; where applicable, a standard shall be calculated for both carcinogenic and noncarcinogenic health effects and the lower of the two values shall serve as the standard.

A2.1.1 Carcinogenic Health Effects

$$\mathbf{GW_1 \text{ or } GW_2 \text{ (ug/l)}} = \frac{1}{\frac{1}{\text{Ingestion}} + \frac{1}{\text{Inhalation}} + \frac{1}{\text{Dermal}}}$$

Ingestion (ug/l) =

$$\frac{TR \times AT_r \left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{CSF_o \left(\frac{mg}{kg\text{-}day}\right)^{-1} \times \left(IFW_{adj} \left(\frac{327.95\ L\text{-}Year}{Kg\text{-}day}\right)\right)}$$

where:

$$IFW_{adj} \left(\frac{327.95\ L\text{-}Year}{Kg\text{-}day}\right) = \frac{EF_{ressc} \left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_c\ (6\ \text{years}) \times IRW_c \left(\frac{0.78\ L}{day}\right)}{BW_c\ (15\ Kg)} + \frac{EF_{ressa} \left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_r\text{-}ED_c\ (20\ \text{years}) \times IRW_a \left(\frac{2.5\ L}{day}\right)}{BW_a\ (80\ Kg)}$$

Inhalation (ug/l) =

$$\frac{TR \times AT_r \left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}{EF_r \left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_r\ (26\ \text{years}) \times ET_{rw} \left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times IUR \left(\mu g/m^3\right)^{-1} \times K \left(\frac{0.5\ L}{m^3}\right)}$$

FOR INORGANICS:

Dermal (ug/l) =

$$\frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hr}\right)\times ET_{rw\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)}$$

FOR ORGANICS:

IF $ET_{rw\text{-}adj}\left(\frac{hours}{event}\right) \le t^*\ (hr)$, then SL, **Dermal (ug/l) =**

$$\frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{2\times FA\times K_p\left(\frac{cm}{hr}\right)\sqrt{\frac{6\times \tau_{event}\left(\frac{hours}{event}\right)\times ET_{rw\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)}{\pi}}}$$

or,

IF $ET_{rw\text{-}adj}\left(\frac{hours}{event}\right) > t^*\ (hr)$, then **Dermal (ug/l) =**

$$\frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{FA\times K_p\left(\frac{cm}{hr}\right)\times\left[\frac{ET_{rw\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)=\frac{TR\times AT_r\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{\left(\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\right)\times DFW_{adj}\left(\frac{2721670\ cm^2\text{-event-day}}{kg}\right)}$$

where:

$$DFW_{adj}\left(\frac{2721670\ cm^2\text{-event-day}}{kg}\right)=\frac{EF_{ressc}\left(\frac{350\ days}{year}\right)\times EV_c\left(\frac{1\ events}{day}\right)\times ED_c\ (6\ years)\times SA_c\left(6378\ cm^2\right)}{BW_c\ (15\ Kg)}+\frac{EF_{ressa}\left(\frac{350\ days}{year}\right)\times EV_a\left(\frac{1\ events}{day}\right)\times ED_a\ (20\ years)\times SA_a\left(20900\ cm^2\right)}{BW_a\ (80\ Kg)}$$

and:

$$ET_{rw\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)=\frac{\left(ET_{rwc}\left(\frac{0.54\ hours}{event}\right)\times ED_c\ (6\ years)+ET_{rwa}\left(\frac{0.71\ hours}{event}\right)\times ED_r\text{-}ED_c\ (20\ years)\right)}{ED_r\ (26\ years)}$$

A2.1.2 Mutagenic Health Effects

GW_1 or GW_2 (ug/l) =

$$\frac{1}{\frac{1}{\text{Ingestion}}+\frac{1}{\text{Inhalation}}+\frac{1}{\text{Dermal}}}$$

Ingestion (ug/l) =

$$\frac{TR \times AT_r\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1} \times IFWM_{adj}\left(\frac{1019.9\ \text{L-Year}}{Kg\text{-}day}\right)}$$

where:

$$IFWM_{adj}\left(\frac{1019.9\ \text{L-Year}}{Kg\text{-}day}\right)=\frac{EF_{ressc}\left(\frac{350\ \text{days}}{\text{year}}\right)\times ED_{0\text{-}2}\ (yr)\times IRW_c\left(\frac{0.78\ L}{day}\right)\times 10}{BW_c\ (15\ Kg)}+\frac{EF_{ressc}\left(\frac{350\ \text{days}}{\text{year}}\right)\times ED_{2\text{-}6}\ (yr)\times IRW_c\left(\frac{0.78\ L}{day}\right)\times 3}{BW_c\ (15\ Kg)}+$$

$$\frac{EF_{ressa}\left(\frac{350\ \text{days}}{\text{year}}\right)\times ED_{6\text{-}16}\ (yr)\times IRW_a\left(\frac{2.5\ L}{day}\right)\times 3}{BW_a\ (80\ Kg)}+\frac{EF_{ressa}\left(\frac{350\ \text{days}}{\text{year}}\right)\times ED_{16\text{-}26}\ (yr)\times IRW_a\left(\frac{2.5\ L}{day}\right)\times 1}{BW_a\ (80\ Kg)}$$

Dermal (ug/l) =

FOR INORGANICS:

Dermal (ug/l) =

$$\frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hr}\right)\times ET_{rw\text{-}madj}\left(\frac{0.6708\ hours}{event}\right)}$$

FOR ORGANICS:

IF $ET_{rw\text{-}madj}\left(\frac{0.6708\ hours}{event}\right) \le t^*\ (hr)$, then **Dermal (ug/l) =**

$$\frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{2\times FA\times K_p\left(\frac{cm}{hr}\right)\sqrt{\frac{6\times \tau_{event}\left(\frac{hours}{event}\right)\times ET_{rw\text{-}madj}\left(\frac{hours}{event}\right)}{\pi}}}$$

or,

IF $ET_{rw\text{-}madj}\left(\frac{0.6708\ hours}{event}\right) > t^*\ (hr)$, then **Dermal (ug/l) =**

$$\frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{FA\times K_p\left(\frac{cm}{hr}\right)\times\left[\frac{ET_{rdw\text{-}madj}\left(\frac{hours}{event}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)=\frac{TR\times AT_r\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{\left(\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\right)\times DFWM_{adj}\left(\frac{8419740\ events\text{-}cm^2}{kg}\right)\times EF_r\left(\frac{350\ days}{year}\right)}$$

where:

$$DFWM_{adj}\left(\frac{8419740\ events\text{-}cm^2}{kg}\right)=\left[\begin{array}{l}\left(\frac{EV_{0\text{-}2}\left(\frac{1\ events}{day}\right)\times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times ED_{0\text{-}2}\ (years)\times SA_c\left(6378\ cm^2\right)\times 10}{BW_c\ (15\ Kg)}\right)+\left(\frac{EV_{2\text{-}6}\left(\frac{1\ events}{day}\right)\times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times ED_{2\text{-}6}\ (years)\times SA_c\left(6378\ cm^2\right)\times 3}{BW_c\ (15\ Kg)}\right)+\\ \left(\frac{EV_{6\text{-}16}\left(\frac{1\ events}{day}\right)\times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times ED_{6\text{-}16}\ (years)\times SA_a\left(20900\ cm^2\right)\times 3}{BW_a\ (80\ Kg)}\right)+\left(\frac{EV_{16\text{-}26}\left(\frac{1\ events}{day}\right)\times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times ED_{16\text{-}26}\ (years)\times SA_a\left(20900\ cm^2\right)\times 1}{BW_a\ (80\ Kg)}\right)\end{array}\right]$$

and:

$$ET_{rw\text{-}madj}\left(\frac{0.6708\ hours}{event}\right)=\frac{\left(\begin{array}{l}ET_{0\text{-}2}\left(\frac{0.54\ hours}{event}\right)\times ED_{0\text{-}2}\ (years)+ET_{2\text{-}6}\left(\frac{0.54\ hours}{event}\right)\times ED_{2\text{-}6}\ (years)+\\ ET_{6\text{-}16}\left(\frac{0.71\ hours}{event}\right)\times ED_{6\text{-}16}\ (years)+ET_{16\text{-}26}\left(\frac{0.71\ hours}{event}\right)\times ED_{16-26}\ (years)\end{array}\right)}{ED_{0\text{-}2}\ (years)+ED_{2\text{-}6}\ (years)+ED_{6\text{-}16}\ (years)+ED_{16\text{-}26}\ (years)}$$

Inhalation (ug/l) =

$$\frac{TR \times AT_r \left(\frac{365\ \text{days}}{\text{year}} \times LT\,(70\ \text{years})\right)}{EF_r \left(\frac{350\ \text{days}}{\text{year}}\right) \times K \left(\frac{0.5\ L}{m^3}\right) \times ET_{rw} \left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \left(\left(ED_{0\text{-}2}\,(\text{yrs}) \times IUR \left(\mu g/m^3\right)^{-1} \times 10\right) + \left(ED_{2\text{-}6}\,(\text{yrs}) \times IUR \left(\mu g/m^3\right)^{-1} \times 3\right) + \left(ED_{6\text{-}16}\,(\text{yrs}) \times IUR \left(\mu g/m^3\right)^{-1} \times 3\right) + \left(ED_{16\text{-}26}\,(\text{yrs}) \times IUR \left(\mu g/m^3\right)^{-1} \times 1\right)\right)}$$

A2.1.3 Vinyl Chloride Carcinogenic Health Effects

GW_1 or GW_2 (ug/l) =

$$\frac{1}{\frac{1}{\text{Ingestion}} + \frac{1}{\text{Inhalation}} + \frac{1}{\text{Dermal}}}$$

Ingestion (ug/l) =

$$\frac{TR}{\left(\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}\times FW_{adj}\left(\frac{327.95\ L\text{-}yr}{kg\text{-}day}\right)\times\left(\frac{mg}{1000\ \mu g}\right)}{AT\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)}\right)+\left(\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}\times IRW_c\left(\frac{0.78\ L}{day}\right)\times\left(\frac{mg}{1000\ \mu g}\right)}{BW_c\left(15\ kg\right)}\right)}$$

where:

$$IFW_{adj}\left(\frac{327.95\ L\text{-}Year}{Kg\text{-}day}\right)=\frac{EF_{ressc}\left(\frac{350\ days}{year}\right)\times IED_c\left(6\ years\right)\times IRW_c\left(\frac{0.78\ L}{day}\right)}{BW_c\left(15\ Kg\right)}+\frac{EF_{ressa}\left(\frac{350\ days}{year}\right)\times IED_r\text{-}ED_c\left(20\ years\right)\times IRW_a\left(\frac{2.5\ L}{day}\right)}{BW_a\left(80\ Kg\right)}$$

Inhalation (ug/l) =

$$\frac{TR}{\left(\frac{IUR\left(\mu g/m^3\right)^{-1}\times EF\left(\frac{350\ days}{year}\right)\times ED\left(30\ years\right)\times ET_{rw}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times K\left(\frac{0.5\ L}{m^3}\right)}{AT\left(\frac{365\ days}{year}\times LT\left(70\ years\right)\right)}\right)+\left(IUR\left(\mu g/m^3\right)^{-1}\times K\left(\frac{0.5\ L}{m^3}\right)\right)}$$

IF $ET_{rw\text{-}adj}\left(\frac{0.6708\ hours}{event}\right) \le t^{*}\ (hr)$, then **Dermal (ug/l) =**

$$\frac{DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{2\times FA\times K_p\left(\frac{cm}{hr}\right)\sqrt{\frac{6\times\tau_{event}\left(\frac{hours}{event}\right)\times ET_{rw\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)}{\pi}}}$$

or,

IF $ET_{rw\text{-}adj}\left(\frac{0.6708\ hours}{event}\right) > t^{*}\ (hr)$, then **Dermal (ug/l) =**

$$\frac{DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{FA\times K_p\left(\frac{cm}{hr}\right)\times\left[\frac{ET_{rw\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right)=\frac{TR}{\left(\frac{\left(\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\right)\times EF_r\left(\frac{350\ days}{year}\right)\times DFW_{adj}\left(\frac{2721670\ cm^2\text{-}events}{kg}\right)}{AT_r\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}\right)+\left(\frac{\left(\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\right)\times EV_{rdwc}\left(\frac{1events}{day}\right)\times SA_c\left(6378\ cm^2\right)}{BW_c\ (15\ Kg)\times\left(\frac{1000\ \mu g}{mg}\right)}\right)}$$

where:

$$DFW_{adj}\left(\frac{2721670\ cm^2\text{-}event}{kg}\right)=\frac{EF_{ressc}\left(\frac{350\ days}{year}\right)\times EV_c\left(\frac{1\ events}{day}\right)\times ED_c\ (6\ years)\times SA_c\left(6378\ cm^2\right)}{BW_c\ (15\ Kg)}+\frac{EF_{ressa}\left(\frac{350\ days}{year}\right)\times EV_a\left(\frac{1\ events}{day}\right)\times ED_a\ (20\ years)\times SA_a\left(20900\ cm^2\right)}{BW_a\ (80\ Kg)}$$

and:

$$ET_{rw\text{-}adj}\left(\frac{0.6708\ hours}{event}\right)=\frac{\left(ET_{rwc}\left(\frac{0.54\ hours}{event}\right)\times ED_c\ (6\ years)\right)+\left(ET_{rwa}\left(\frac{0.71\ hours}{event}\right)\times ED_r-ED_c\ (20\ years)\right)}{ED_r\ (26\ years)}$$

A2.1.4 Trichloroethylene - Carcinogenic and Mutagenic

GW_1 and GW_2 (ug/l) =

$$\frac{1}{\frac{1}{\text{Ingestion}}+\frac{1}{\text{Inhalation}}+\frac{1}{\text{Dermal}}}$$

Ingestion (ug/l) =

$$\frac{TR \times AT_{resw}\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times \left(\left(CAF_o\ (0.804) \times IFW_{resw\text{-}adj}\left(\frac{327.95\ L}{Kg}\right)\right)\right) + \left(MAF_o\ (0.202) \times IFWM_{res\text{-}adj}\left(\frac{1019.9\ L}{Kg}\right)\right)}$$

where:

$$IFW_{resw\text{-}adj}\left(\frac{327.95\ L}{Kg}\right) = \frac{ED_{reswc}\ (6\ \text{years}) \times EF_{reswc}\left(\frac{350\ \text{days}}{\text{year}}\right) \times IRW_{reswc}\left(\frac{0.78\ L}{\text{day}}\right)}{BW_c\ (15\ Kg)} + \frac{ED_{resw}\ (26\ \text{years}) - ED_{reswc}\ (6\ \text{years}) \times EF_{reswa}\left(\frac{350\ \text{days}}{\text{year}}\right) \times IRW_{reswa}\left(\frac{2.5\ L}{\text{day}}\right)}{BW_{reswa}\ (80\ Kg)}$$

where:

$$IFWM_{res\text{-}adj\text{-}}\left(\frac{1019.9\ L}{Kg}\right) = \frac{ED_{0\text{-}2}\ (2\ \text{years}) \times EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times IRW_{0\text{-}2}\left(\frac{0.78\ L}{\text{day}}\right) \times 10}{BW_{0\text{-}2}\ (15\ Kg)} + \frac{ED_{2\text{-}6}\ (4\ \text{years}) \times EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times IRW_{2\text{-}6}\left(\frac{0.78\ L}{\text{day}}\right) \times 3}{BW_{2\text{-}6}\ (15\ Kg)} + \frac{ED_{6\text{-}16}\ (10\ \text{years}) \times EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times IRW_{6\text{-}16}\left(\frac{2.5\ L}{\text{day}}\right) \times 3}{BW_{6\text{-}16}\ (80\ Kg)} + \frac{ED_{16\text{-}26}\ (10\ \text{years}) \times EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times IRW_{16\text{-}26}\left(\frac{2.5\ L}{\text{day}}\right) \times 1}{BW_{16\text{-}26}\ (80\ Kg)}$$

Inhalation (ug/l) =

$$\frac{TR \times AT_{resw}\left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}{ET_{resw}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times K\left(\frac{0.5\ \text{L}}{m^3}\right) \times IUR\left(\mu g/m^3\right)^{-1} \times \left(\left(EF_{resw}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{resw}\ (30\ \text{years}) \times CAF_i\ (0.756)\right) + \left(\left(\left(ED_{0\text{-}2}\ (2\ \text{years}) \times EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times MAF_i\ (0.244) \times 10\right) + \left(ED_{2\text{-}6}\ (4\ \text{years}) \times EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times MAF_i\ (0.244) \times 3\right) + \left(ED_{6\text{-}16}\ (10\ \text{years}) \times EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times MAF_i\ (0.244) \times 3\right) + \left(ED_{16\text{-}26}\ (10\ \text{years}) \times EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times MAF_i\ (0.244) \times 1\right)\right)\right)\right)}$$

FOR ORGANICS:

IF $ET_{resw\text{-}adj}\left(\frac{hours}{event}\right) \le t^{*}\ (hr)$, then **Dermal (ug/l) =**

$$\frac{DA_{tce\text{-}event}\left(\frac{ug}{cm^2\text{-}event}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{2\times FA\times K_p\left(\frac{cm}{hr}\right)\sqrt{\frac{6\times\tau_{event}\left(\frac{hours}{event}\right)\times ET_{resw\text{-}madj}\left(\frac{0.6708\ hours}{event}\right)}{\pi}}}$$

or,

IF $ET_{resw\text{-}adj}\left(\frac{hours}{event}\right) > t^{*}\ (hr)$, then **Dermal (ug/l) =**

$$\frac{DA_{tce\text{-}event}\left(\frac{ug}{cm^2\text{-}event}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{FA\times K_p\left(\frac{cm}{hr}\right)\times\left[\frac{ET_{resw\text{-}madj}\left(\frac{0.6708\ hours}{event}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{tce\text{-}event}\left(\frac{ug}{cm^2\text{-}event}\right)=\frac{TR\times AT_{resw}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)}{\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\times\left(\left(AF_o\ (0.804)\times DFW_{res\text{-}adj}\left(\frac{2721670\ cm^2\text{-}event\text{-}day}{kg}\right)\right)+\left(MAF_o\ (0.202)\times DFWM_{res\text{-}adj}\left(\frac{8419740\ events\text{-}cm^2}{kg}\right)\right)\right)}$$

where:

$$DFW_{res\text{-}adj}\left(\frac{2721670\ cm^2\text{-}event\text{-}day}{kg}\right)=\frac{EV_{reswc}\left(\frac{1\ events}{day}\right)\times ED_{reswc}\ (6\ years)\times EF_{reswc}\left(\frac{350\ days}{year}\right)\times SA_{reswc}\left(6378\ cm^2\right)}{BW_{resw}\ (15\ Kg)}+$$

$$\frac{EV_{reswa}\left(\frac{1\ events}{day}\right)\times ED_{reswa}\ (20\ years)\times EF_{reswa}\left(\frac{350\ days}{year}\right)\times SA_{reswa}\left(20900\ cm^2\right)}{BW_{reswa}\ (80\ Kg)}$$

where:

$$DFWM_{res\text{-}adj}\left(\frac{8419740\ events\text{-}cm^2}{kg}\right)=\left[\begin{array}{l}\left(\frac{EV_{0\text{-}2}\left(\frac{1\ events}{day}\right)\times ED_{0\text{-}2}\ (2\ years)\times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times SA_{0\text{-}2}\left(6378\ cm^2\right)\times 10}{BW_{0\text{-}2}\ (15\ Kg)}\right)+\\ \left(\frac{EV_{2\text{-}6}\left(\frac{1\ events}{day}\right)\times ED_{2\text{-}6}\ (4\ years)\times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times SA_{2\text{-}6}\left(6378\ cm^2\right)\times 3}{BW_{2\text{-}6}\ (15\ Kg)}\right)+\\ \left(\frac{EV_{6\text{-}16}\left(\frac{1\ events}{day}\right)\times ED_{6\text{-}16}\ (10\ years)\times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times SA_{6\text{-}16}\left(20900\ cm^2\right)\times 3}{BW_{6\text{-}16}\ (80\ Kg)}\right)+\\ \left(\frac{EV_{16\text{-}26}\left(\frac{1\ events}{day}\right)\times ED_{16\text{-}26}\ (10\ years)\times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times SA_{16\text{-}26}\left(20900\ cm^2\right)\times 1}{BW_{16\text{-}26}\ (80\ Kg)}\right)\end{array}\right]$$

and:

$$ET_{resw\text{-}madj}\left(\frac{0.6708\ hours}{event}\right)=\frac{\left(\begin{array}{l}ET_{0\text{-}2}\left(\frac{0.54\ hours}{event}\right)\times ED_{0\text{-}2}\ (years)+ET_{2\text{-}6}\left(\frac{0.54\ hours}{event}\right)\times ED_{2\text{-}6}\ (years)+\\ ET_{6\text{-}16}\left(\frac{0.71\ hours}{event}\right)\times ED_{6\text{-}16}\ (years)+ET_{16\text{-}26}\left(\frac{0.71\ hours}{event}\right)\times ED_{16\text{-}26}\ (years)\end{array}\right)}{ED_{0\text{-}2}\ (years)+ED_{2\text{-}6}\ (years)+ED_{6\text{-}16}\ (years)+ED_{16\text{-}26}\ (years)}$$

$$CAF_o(0.804) = \frac{CSF_o\left(\frac{3.7\times10^{-2}\,mg}{Kg\text{-}day}\right)^{-1}\ \text{NHL+Liver oral slope factor}}{CSF_o\left(\frac{4.6\times10^{-2}\,mg}{Kg\text{-}day}\right)^{-1}\ \text{Adult-based oral slope factor}}$$

$$MAF_o(0.202) = \frac{CSF_o\left(\frac{9.3\times10^{-3}\,mg}{Kg\text{-}day}\right)^{-1}\ \text{Kidney oral slope factor}}{CSF_o\left(\frac{4.6\times10^{-2}\,mg}{Kg\text{-}day}\right)^{-1}\ \text{Adult-based oral slope factor}}$$

$$CAF_i(0.756) = \frac{IUR\left(3.1\times10^{-6}\,\mu g/m^3\right)^{-1}\ \text{NHL+Liver unit risk estimate}}{IUR\left(4.1\times10^{-6}\,\mu g/m^3\right)^{-1}\ \text{Adult-based unit risk estimate}}$$

$$MAF_i(0.244) = \frac{IUR\left(1\times10^{-6}\,\mu g/m^3\right)^{-1}\ \text{Kidney unit risk estimate}}{IUR\left(4.1\times10^{-6}\,\mu g/m^3\right)^{-1}\ \text{Adult-based unit risk estimate}}$$

A2.1.5 Noncarcinogenic Health Effects

GW_1 and GW_2 (ug/l) =

$$\frac{1}{\frac{1}{\text{Ingestion}}+\frac{1}{\text{Inhalation}}+\frac{1}{\text{Dermal}}}$$

Ingestion (ug/l) =

$$\frac{THQ \times AT_r\left(\frac{365\ \text{days}}{\text{year}} \times ED_c\ (6\ \text{years})\right) \times BW_c\ (15\ \text{Kg}) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_r\left(350\ \frac{\text{days}}{\text{year}}\right) \times ED_c\ (6\ \text{years}) \times \frac{1}{RfD_o\left(\frac{mg}{kg\text{-}d}\right)} \times IRW_c\left(\frac{0.78\ L}{day}\right)}$$

Inhalation (ug/l) =

$$\frac{THQ \times AT_r\left(\frac{365\ \text{days}}{\text{year}} \times ED_c\ (6\ \text{years})\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_r\left(350\ \frac{\text{days}}{\text{year}}\right) \times ED_c\ (6\ \text{years}) \times ET_{rw}\left(\frac{24\ \text{hours}}{day}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \frac{1}{RfC\left(mg/m^3\right)} \times K\left(\frac{0.5\ L}{m^3}\right)}$$

FOR INORGANICS:

Dermal (ug/l) =

$$\frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hr}\right)\times ET_{rwc}\left(\frac{1\ hours}{event}\right)}$$

FOR ORGANICS:

IF $ET_{rwc}\left(\frac{0.54\ hours}{event}\right) \le t^*\ (hr)$, then **Dermal (ug/l) =**

$$\frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{2\times FA\times K_p\left(\frac{cm}{hr}\right)\sqrt{\frac{6\times\tau_{event}\left(\frac{hours}{event}\right)\times ET_{rwc}\left(\frac{0.54\ hours}{event}\right)}{\pi}}}$$

or,

IF $ET_{rwc}\left(\frac{0.54\ hours}{event}\right) > t^*\ (hr)$, then **Dermal (ug/l) =**

$$\frac{DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)\times\left(\frac{1000\ cm^3}{L}\right)}{FA\times K_p\left(\frac{cm}{hr}\right)\times\left[\frac{ET_{rwc}\left(\frac{0.54\ hours}{event}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{- event}}\right)=\frac{THQ\times AT_r\left(\frac{365\ days}{year}\times ED_c\ (6\ years)\right)\times\left(\frac{1000\ \mu g}{mg}\right)\times BW_c\ (15\ Kg)}{\left(\frac{1}{RfD_o\left(\frac{mg}{Kg\text{-}day}\right)\times GIABS}\right)\times EV_c\left(\frac{1\ events}{day}\right)\times ED_c\ (6\ years)\times EF\left(\frac{350\ days}{year}\right)\times SA_c\ (6378\ cm^2)}$$

A2.2 Groundwater Classification 3

The GW_{3NDW} and GW_{3DW} shall be obtained from Table 3. For the generation of Table 3, the procedures described below were used for the identification or calculation of the GW RS. If a constituent is not listed in Table 3, a GW_{3NDW} or GW_{3DW} shall be identified or calculated based on the procedures presented below. The risk-based criteria shall be based on: 1) the equations presented in this appendix; 2) toxicity values selected in accordance with the hierarchy defined in Section 2.4; 3) a target cancer risk and target hazard quotient as specified in Section 2.5; and 4) *EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites* calculator physical/chemical properties and TPHCWG physical/chemical properties for aliphatic and aromatic hydrocarbon fractions. Note: No substitutions shall be made for the input values presented below for the calculation of the GW_{3NDW} and GW_{3NDW}. The objective of the GW_3 RS is to provide protection against the migration and discharge of a COC in groundwater to a surface water body. Although risk-based standards are used to evaluated the acceptability of a COC concentration with respect to the protection of surface water, the GW_3 RS is considered a fate and transport standard and therefore does not require adjustment for potential additive health effects.

A2.2.1 GW_{3NDW}

Protection of Surface Water Classified as a Non-Drinking Water Supply

The State human health protection non-drinking water supply criterion in LAC 33:IX.1113, Table 1 shall be used as the GW_{3NDW}. If a State human health protection non-drinking water supply criterion is not available, then the highest of the following three values shall serve as the GW_{3NDW}: 1) a risk-based criterion calculated as presented below; if applicable criteria shall be calculated for both carcinogenic health effects and noncarcinogenic health effects and the lower of the two values shall be selected as the risk-based criterion; 2) the MCL; and (3) the State human health protection drinking water supply criterion. Note: No substitutions shall be made for the input values presented below for the calculation of the GW_{3NDW}.

A2.2.1.1 Carcinogenic Health Effects

$$GW_{3NDW}\ (mg/l) = \frac{TR \times BW_a}{SF_o[IRW_{NDW} + (BCF \times IRF)]}$$

where:

Parameter	Definition (units)	Input Value
GW_{3NDW}	constituent concentration in groundwater that is protective of surface water (mg/l)	--

TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]
BW_a	average adult body weight (kg)	70 [a]
IRF	fish/shellfish ingestion rate (kg/day)	0.02 [a]
SF_o	oral cancer slope factor ($(mg/kg\text{-}day)^{-1}$)	constituent-specific
IRW_{NDW}	incidental water ingestion rate (L/day)	0.089 [a,c]
BCF	bioconcentration factor (L/kg)	constituent-specific [d]

[a] *Standard Operating Procedure for Human Health Criteria Calculations for Toxic Substance in Louisiana*, Water Permits Division Office of Environmental Services, LDEQ 2016.

[b] An fish ingestion rate of 0.02 kg/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. For water bodies designated as classification B secondary contact recreation and limited aquatic and wildlife use, a fish ingestion rate of 0.0065 kg/day shall be used.

[c] An incidental ingestion rate of 0.089 L/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. This rate is based on the following assumptions: 250 mL/hr possible ingestion X 5 hrs/week swimming duration X 6 months/12 months swimming season X 1 week/7 days = 0.089 L/day incidental ingestion. For water bodies designated as classification B secondary contact recreation and limited aquatic and wildlife use, an incidential water ingestion rate of 0 L/day shall be used.

[d] If there is potential for a COC to be bioconcentrated by fish and a BCF value is not available for the COC, then a BCF may be estimated using the K_{ow} or using another appropriate model approved by the Department.

$$\log BCF = 0.76 \log K_{ow} - 0.23$$

where:

Parameter	**Definition**	**Input Value**
BCF	Bioconcentration factor (L/kg)	chemical-specific
K_{ow}	Octanol-water partition coefficient	chemical-specific

(Fundamentals of Aquatic Toxicology. 1985. Ed. Rand and S. Petrocelli, Washington: Hemisphere Publishing Corp., Chapter 17, Bioaccumulation, A. Ipacie and J. L. Hamelink)

A2.2.1.2 Noncarcinogenic Health Effects

$$GW_{3NDW}\ (mg/l) = \frac{THQ \times RfD_o \times BW_a}{IRW_{NDW} + (BCF \times IRF)}$$

where:

Parameter	Definition (units)	Input Value
GW_{3NDW}	constituent concentration in groundwater water that is protective of surface water (mg/l)	--
THQ	target hazard quotient (unitless)	1.0 [a]
BW_a	average adult body weight (kg)	70 [a]
IRF	fish/shellfish ingestion rate (kg/day)	0.02 [a]
RfD_o	oral reference dose (mg/kg-day)	CS [c]
IRW_{NDW}	incidental water ingestion rate (L/day)	0.089 [a,d]
BCF	bioconcentration factor (L/kg)	CS [c,e]

[a] *Standard Operating Procedure for Human Health Criteria Calculations for Toxic Substance in Louisiana*, Water Permits Division Office of Environmental Services, LDEQ 2016.

[b] An fish ingestion rate of 0.02 kg/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. For water bodies designated as classification B secondary contact recreation and limited aquatic and wildlife use, a fish ingestion rate of 0.0065 kg/day shall be used.

[c] Chemical-specific

[d] An incidental ingestion rate of 0.089 L/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. This rate is based on the following assumptions: 250 mL/hr possible ingestion X 5 hrs/week swimming duration X 6 months/12 months swimming season X 1 week/7 days = 0.089 L/day incidental ingestion. For water bodies designated as classification B secondary contact recreation and limited aquatic and wildlife use, an incidential water ingestion rate of 0.089 L/day shall be used.

[e] If there is potential for a COC to be bioconcentrated by fish and a BCF value is not available for the COC, then a BCF may be estimated using the K_{ow} or another appropriate model approved by the Department.

A2.2.2 GW_{3DW}

Protection of Surface Water Classified as a Drinking Water Supply

The State human health protection drinking water supply criterion in LAC 33:IX.1113, Table 1 shall be used as the GW_{3DW}. If a State human health protection drinking water supply criterion is not available, then the MCL shall be used. If an MCL is not available for a COC, then a risk-based criterion shall be developed using the equation presented below. If applicable criteria shall be calculated for both carcinogenic health effects and noncarcinogenic health effects and the lower of the two values shall be selected as the risk-based criterion. Note: No substitutions shall be made for the input values presented below for the calculation of the GW_{3DW}. It should be noted that metals are hardness-dependent. The criteria listed in LAC 33:IX.1113, Table 1 assume a hardness of 50 mg/l. Site-specific criteria may be calculated using the natural logarithm formulas at LAC 33:IX.1113, Table 1. Drinking water supply is a raw water source which may require treatment before use (defined at LAC 33:IX.1105).

A2.2.2.1 Carcinogenic Health Effects

$$GW_{3DW}\ (mg/) = \frac{TR\,x\,BW_a}{SF_o\,x\left[IRW_a + IRW_{NDW} + \left(BCF\,x\,IRF\right)\right]}$$

where:

Parameter	Definition (units)	Input Value
GW_{3DW}	constituent concentration in groundwater that is protective of surface water (mg/l)	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]
BW_a	average adult body weight (kg)	70 [a]
IRF	fish/shellfish ingestion rate (kg/day)	0.02 [a]
SF_o	oral cancer slope factor ($(mg/kg\text{-}day)^{-1}$)	CS [b]
IRW_a	adult water ingestion rate (L/day)	2 [a]
IRW_{NDW}	incidental water ingestion rate (L/day)	0.089 [a,c]
BCF	bioconcentration factor (L/kg)	CS [b,d]

[a] *Standard Operating Procedure for Human Health Criteria Calculations for Toxic Substance in Louisiana*, Water Permits Division Office of Environmental Services, LDEQ 2016.

[b] Chemical-specific

[c] An incidental ingestion rate of 0.089 L/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. This rate is based on the following assumptions: 250 mL/hr possible ingestion X 5 hrs/week swimming duration X 6 months/12 months swimming season X 1 week/7 days = 0.089 L/day incidental ingestion.

[d] If there is potential for a COC to be bioconcentrated by fish and a BCF value is not available for the COC, then a BCF may be estimated using the K_{ow} or another appropriate model approved by the Department.

A2.2.2.2 Noncarcinogenic Health Effects

$$GW_{3DW}\ (mg/l) = \frac{THQ\,x\,RfD_o\,x\,BW_a}{IRW_a + IRW_{NDW} + (BCF\,x\,IRF)}$$

where:

Parameter	Definition (units)	Input Value
GW_{3DW}	constituent concentration in groundwater that is protective of surface water (mg/l)	--
THQ	target hazard quotient (unitless)	1.0 [a]
BW_a	average adult body weight (kg)	70 [a]
IRF	fish/shellfish ingestion rate (kg/day)	0.02 [a]
RfD_o	oral reference dose (mg/kg-day)	CS [b]
IRW_a	adult water ingestion rate (L/day)	2 [a]
IRW_{NDW}	incidental water ingestion rate (L/day)	0.089 [a,c]
BCF	bioconcentration factor (L/kg)	CS [b,d]

[a] *Standard Operating Procedure for Human Health Criteria Calculations for Toxic Substance in Louisiana*, Water Permits Division Office of Environmental Services, LDEQ 2016.

[b] Chemical-specific

[c] An incidental ingestion rate of 0.089 L/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. This rate is based on the following assumptions: 250 mL/hr possible ingestion X 5 hrs/week swimming duration X 6 months/12 months swimming season X 1 week/7 days = 0.089 L/day incidental ingestion.

[d] If there is potential for a COC to be bioconcentrated by fish and a BCF value is not available for the COC, then a BCF may be estimated using the K_{ow} or another appropriate model approved by the Department.

A2.3 Water Solubility($Water_{sol}$)

The water solubility ($Water_{sol}$) shall be considered in the identification of the limiting groundwater RS for Groundwater Classifications 1, 2, and 3. A $Water_{sol}$ value used as a RS is subject to Department approval.

A3.0 ENCLOSED STRUCTURE VAPOR CONCENTRATION FOR THE VAPOR INTRUSION PATHWAY (VI)

The enclosed structure vapor concentration standard (VC) shall be based on the Louisiana Toxic Air Pollutant Ambient Air Standards in Table 51.2 of LAC 33:III.5112. If the COC is a noncarcinogen, the 8-hour average ambient air standard shall serve as the VC. If the COC is a carcinogen, the annual average ambient air standard will serve as the VC. For COC not listed in Table 51.2, refer to Table 4 of the main document for the risk-based VC. If a COC is not listed in Table 51.2 or Table 4, then a risk-based standard shall be calculated in accordance with Sections A3.1 and A3.2. If approved by the Department, a risk-based value calculated using site-specific data under MO-3 or other risk-based value determined to be acceptable for site-specific conditions may be used as the VC_i. If multiple COC are present, the risk-based VC shall be adjusted to account for additive health effects as warranted based on site-specific conditions. As a general rule, a constituent is considered to be volatile if : 1) the vapor pressure is greater than 1mm Hg; or 2) the Henry's Law Constant is greater than or equal to 1E-05 atm-m3/mol and the molecular weight is less than or equal to 200 g/mole. Other factors requiring consideration for certain constituents and media include analytical methodologies and limitations (e.g. petroleum fractions in air). Refer to Section A4.0 for symbol definitions and input values. Enclosed structure vapor concentration standards shall contain 2 significant digits.

A3.1 Non-Industrial Vapor Intrusion Enclosed Structure Vapor Concentration (VC_{ni})

A3.1.1 Carcinogenic Health Effects

$$VC_{ni}\ (ug/m^3) = \frac{TR \times AT_r \left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}{EF_r \left(\frac{350\ days}{year}\right) \times ED_r\ (26\ years) \times ET_{ra} \left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IUR \left(\mu g/m^3\right)^{-1}}$$

A3.1.2 Mutagenic Effects

$$VC_{ni}\ (ug/m^3) = \frac{TR \times AT_r\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}{\left(\frac{1\ day}{24\ hours}\right) \times \left(\begin{array}{l} \left(ED_{0\text{-}2}\ (yrs) \times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right) \times ET_{0\text{-}2}\left(\frac{24\ hours}{day}\right) \times IUR\left(\mu g/m^3\right)^{-1} \times 10\right) + \\ \left(ED_{2\text{-}6}\ (yrs) \times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right) \times ET_{2\text{-}6}\left(\frac{24\ hours}{day}\right) \times IUR\left(\mu g/m^3\right)^{-1} \times 3\right) + \\ \left(ED_{6\text{-}16}\ (yrs) \times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right) \times ET_{6\text{-}16}\left(\frac{24\ hours}{day}\right) \times IUR\left(\mu g/m^3\right)^{-1} \times 3\right) + \\ \left(ED_{16\text{-}26}\ (yrs) \times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right) \times ET_{16\text{-}26}\left(\frac{24\ hours}{day}\right) \times IUR\left(\mu g/m^3\right)^{-1} \times 1\right) \end{array}\right)}$$

A3.1.3 Vinyl Chloride – Carcinogenic Effects

$$VC_{ni}\ (ug/m^3) = \frac{TR}{IUR\left(\mu g/m^3\right)^{-1} + \left(\frac{IUR\left(\mu g/m^3\right)^{-1} \times EF_r\left(\frac{350\ days}{year}\right) \times ED_r\ (26\ years) \times ET_{ra}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right)}{AT_r\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}\right)}$$

A3.1.4 Trichloroethylene – Carcinogenic and Mutagenic Effects

VC_{ni} (ug/m^3) =

$$\frac{TR \times AT_r \left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}{IUR\left(\mu g/m^3\right)^{-1} \times EF_r\left(\frac{350\ \text{days}}{\text{year}}\right) \times ET_{ra}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \left(\begin{array}{l}\left(ED_r\ (30\ \text{years}) \times CAF_i\ (0.756)\right) + \\ \left(\left(ED_{0\text{-}2}\ (\text{yrs}) \times MAF_i\ (0.244) \times 10\right) + \left(ED_{2\text{-}6}\ (\text{yrs}) \times MAF_i\ (0.244) \times 3\right) + \right. \\ \left.\left(ED_{6\text{-}16}\ (\text{yrs}) \times MAF_i\ (0.244) \times 3\right) + \left(ED_{16\text{-}26}\ (\text{yrs}) \times MAF_i\ (0.244) \times 1\right)\right)\end{array}\right)}$$

A3.1.5 Noncarcinogenic Health Effects

VC_{ni} (ug/m^3) =

$$\frac{THQ \times AT_r \left(\frac{365\ \text{days}}{\text{year}} \times ED_r\ (26\ \text{years})\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_r\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_r\ (26\ \text{years}) \times ET_{ra}\left(\frac{24\ \text{hours}}{\text{day}}\right) \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \frac{1}{RfC\left(mg/m^3\right)}}$$

A3.2 Industrial/Commercial Vapor Intrusion Enclosed Structure Vapor Concentration (VC_i)

A3.2.1 Carcinogenic Health Effects

VC_i (ug/m^3) =

$$\frac{TR \times AT_w \left(\frac{365\ \text{days}}{\text{year}} \times LT\ (70\ \text{years})\right)}{EF_w \left(\frac{250\ \text{days}}{\text{year}}\right) \times ED_w\ (25\ \text{years}) \times ET_w \left(\frac{8\ \text{hr}}{24\ \text{hr}}\right) \times IUR \left(\mu g/m^3\right)^{-1}}$$

A3.2.2 Noncarcinogenic Health Effects

VC_i (ug/m^3) =

$$\frac{THQ \times AT_w \left(\frac{365\ \text{days}}{\text{year}} \times ED_w\ (25\ \text{years})\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{EF_w \left(\frac{250\ \text{days}}{\text{year}}\right) \times ED_w\ (25\ \text{years}) \times ET_w \left(\frac{8\ \text{hr}}{24\ \text{hr}}\right) \times \frac{1}{RfC \left(mg/m^3\right)}}$$

A4.0 SYMBOL DEFINITIONS AND DEFAULT INPUT PARAMETERS

The following table lists the EPA and LDEQ recommended default input values for the calculation of Screening Standards and RECAP Standards. The EPA default inputs for $Soil_{ssni}$ and $Soil_{ni}$ (Resident); $Soil_{ssi}$ and $Soil_{i}$ (Composite Worker); $Soil_{SSGW}$, $Soil_{GW1}$ and $Soil_{GW2}$ (Soil to Groundwater) $Soil_{sat}$ (Soil Saturation Limit); GW_{SS}, GW_{1}, and GW_{2} (Tap Water); VC_{ni} (Vapor Concentration non-industrial land use); VC_{i} (Vapor Concentration industrial land use) were obtained from *EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites*. Refer to the *EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites* User's Guide for symbols and/or input values not listed below.

Symbol	Definition (units)	EPA Default	LDEQ Default
Toxicity Values (Refer to RECAP Document Section 2.4)			
RfD_o	Chronic Oral Reference Dose (mg/kg-day)	Constituent-specific	Constituent-specific
RfC	Chronic Inhalation Reference Concentration (mg/m^3)	Constituent-specific	Constituent-specific
CSF_o	Chronic oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Constituent-specific	Constituent-specific
IUR	Chronic Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Constituent-specific	Constituent-specific
Target Risk (Refer to RECAO Document Section 2.5)			
TR	Target risk	1.0E-06	1.0E-06
THQ (SO)	Target hazard quotient	--------	0.1
THQ (MO-1, 2, 3)	Target hazard quotient	1	1
Miscellaneous Variables			
K	Andelman Volatilization Factor (L/m^3)	0.5	0.5
K_p	Dermal Permeability Constant (cm/hr)	Constituent-specific	Constituent-specific
t*	Time to reach steady-state (hours)	Constituent-specific	Constituent-specific
T_{event}	Lag time per event (hours/event)	Constituent-specific	Constituent-specific
B	Ratio of the permeability coefficient through the stratum corneum to the permeability coefficient through the viable epidermis (unitless)	Constituent-specific	Constituent-specific
FA	Fraction of absorbed water (unitless)	Constituent-specific	Constituent-specific
AT_r; AT_{ress}	Averaging time - resident (days/year)	365	365
AT_w	Averaging time – industrial worker (days/year)	365	365
LT	Lifetime (years)	70	70
Ingestion and Dermal Contact Rates			
IRW_c; IRW_{resc}	Resident Drinking Water Ingestion Rate - Child (L/day)	0.78	0.78

IRW_a; IRW_{resa}	Resident Drinking Water Ingestion Rate - Adult (L/day)	2.5	2.5
IRW_{0-2}	Resident Drinking Water Ingestion Rate 0-2 years (kg) (L/day)	0.78	0.78
IRW_{2-6}	Resident Drinking Water Ingestion Rate 2-6 years (kg) (L/day)	0.78	0.78
IRW_{6-16}	Resident Drinking Water Ingestion Rate 6-16 years (kg) (L/day)	2.5	2.5
IRW_{16-26}	Resident Drinking Water Ingestion Rate 16-26 years (kg) (L/day)	2.5	2.5
$IFW_{res-adj}$	Resident Drinking Water Ingestion Rate - Age-adjusted (L-year/kg-day)	327.95	327.95
$IFWM_{res-adj}$	Resident Mutagenic Drinking Water Ingestion Rate - Age-adjusted (L-year/kg-day)	1019.9	1019.9
IRS_c; IRS_{ressc}	Resident Soil Ingestion Rate - Child (mg/day)	200	200
IRS_a; IRS_{ressa}	Resident Soil Ingestion Rate - Adult (mg/day)	100	100
IFS_{adj}; $IRS_{res-adj}$	Resident Soil Ingestion Rate - Age-adjusted (mg-year/kg-day)	36,750	36,750
$IFSM_{adj}$; $IRSM_{res-adj}$	Resident Mutagenic Soil Ingestion Rate - Age-adjusted (mg-year/kg-day)	166,833.33	166,833.33
IR_w	Composite Worker Soil Ingestion Rate (mg/day)	100	100
IRS_{0-2}	Soil Ingestion Rate - Age-segment 0-2 (mg/day)	200	200
IRS_{2-6}	Soil Ingestion Rate - Age-segment 2-6 (mg/day)	200	200
IRS_{6-16}	Soil Ingestion Rate - Age-segment 6-16 (mg/day)	100	100
IRS_{16-26}	Soil Ingestion Rate - Age-segment 16-26 (mg/day)	100	100
$DFS_{res-adj}$	Resident soil dermal contact factor- age-adjusted (mg-year/kg-day)	112,266	112,266
$DFSM_{res-adj}$	Resident Mutagenic soil dermal contact factor- age-adjusted (mg-year/kg-day)	475,598.66	475,598.66
$DFW_{res-adj}$	Resident water dermal contact factor- age-adjusted (cm^2 - event/kg)	2,721,670	2,721,670
$DFWM_{res-adj}$	Resident Mutagenic water dermal contact factor- age-adjusted (cm^2 - event/kg)	Site-specific	Site-specific
SA_c; SA_{ressc}	Resident soil surface area - child (cm^2)	2373	2376
SA_a; SA_{ressa}	Resident soil surface area - adult (cm^2)	6032	6032
SA_{0-2}	Resident Soil Surface Area 0-2 years (cm^2)	2373	2690
SA_{2-6}	Resident Soil Surface Area 2-6 years (cm^2)	2373	2373
SA_{6-16}	Resident Soil Surface Area 6-16 years (cm^2)	6032	6032
SA_{16-26}	Resident Soil Surface Area 16-26 years (cm^2)	6032	6032

SA_c; SA_{reswc}	Resident water surface area - child (cm^2)	6378	6378
SA_a; SA_{reswa}	Resident water surface area - adult (cm^2)	20,900	20,900
SA_{0-2}	Resident Water Surface Area 0-2 years (cm^2)	6378	6378
SA_{2-6}	Resident Water Surface Area 2-6 years (cm^2)	6378	6378
SA_{6-16}	Resident Water Surface Area 6-16 years (cm^2)	20,900	20,900
SA_{16-26}	Resident Water Surface Area 16-26 years (cm^2)	20,900	20,900
SA_{ow}	Worker soil surface area - adult (cm^2)	3527	3527
AF_c; AF_{ressc}	Resident soil adherence factor - child (mg/cm^2)	0.2	0.2
AF_a; AF_{ressa}	Resident soil adherence factor - adult (mg/cm^2)	0.07	0.07
AF_{0-2}	Soil Adherence Factor 0-2 years (mg/cm^2)	0.2	0.2
AF_{2-6}	Soil Adherence Factor 2-6 years (mg/cm^2)	0.2	0.2
AF_{6-16}	Soil Adherence Factor 6-16 years (mg/cm^2)	0.07	0.07
AF_{16-26}	Soil Adherence Factor 16-26 years (mg/cm^2)	0.07	0.07
AF_{ow}	Worker soil adherence factor - child (mg/cm^2)	0.12	0.12
BW_c; BW_{ressc}	Resident Body Weight - child (kg)	15	15
BW_a; BW_{ressa}	Resident Body Weight - adult (kg)	80	80
BW_{0-2}	Resident Body Weight 0-2 years (kg)	15	15
BW_{2-6}	Resident Body Weight 2-6 years (kg)	15	15
BW_{6-16}	Resident Body Weight 6-16 years (kg)	80	80
BW_{16-26}	Resident Body Weight 16-26 years (kg)	80	80
BW_w	Worker Body Weight (kg)	80	80
ABS_d	Fraction of constituent absorbed dermally from soil (unitless)	Constituent-specific	Constituent-specific
	Arsenic	0.03	0.03
	Cadmium	0.001	0.001
	Chlordane	0.04	0.04
	2,4-D	0.05	0.05
	DDT	0.03	0.03
	Gamma-hexchlorocyclohexane	0.04	0.04
	PCDD and PCDF	0.03	0.03
	Pentachlorophenol	0.25	0.25
	Polychlorinated biphenyls	0.14	0.14
	Polycyclic Aromatic Hydrocarbons	0.13	0.13

	Other semivolatile organic constituents Other inorganic consituents (metals) Volatile Constituents	0.10 0 0	0.10 0 0
RBA	Relative bioavailability factor for soil ingestion pathway (arsenic)	0.6	0.6
GIABS	Fraction of constituent absorbed in gastrointestinal tract (unitless) Note: if the GIABS is >50% then it is set to 100% for the calculation of dermal toxicity values.	Constituent-specific	Constituent-specific
DA_{event}	Absorbed dose per event (µg/cm^2 - event)	Constituent-specific	Constituent-specific
Exposure Frequency, Duration, and Time Variables			
EF_r; EF_{ress}; EF_{resw}; EF_{resa}	Resident Exposure Frequency (days/yr)	350	350
EF_{ressa}; EF_{reswa}; EF_{resaa}	Resident Exposure Frequency – adult (days/yr)	350	350
EF_{ressc}; EF_{reswc}; EF_{resac}	Resident Exposure Frequency – child (days/yr)	350	350
EF_w	Worker Exposure Frequency (days/yr)	250	250
EF_{0-2}	Exposure Frequency - age segment 0-2 (days/yr)	350	350
EF_{2-6}	Exposure Frequency - age segment 2-6 (days/yr)	350	350
EF_{6-16}	Exposure Frequency - age segment 6-16 (days/yr)	350	350
EF_{16-26}	Exposure Frequency - age segment 16-26 (days/yr)	350	350
ED_r; ED_{res}; ED_{resa}	Resident Exposure Duration (yr)	26	26
ED_c; ED_{ressc}; ED_{resac}	Resident Exposure Duration - child (yr)	6	6
ED_a; ED_{resas}; ED_{resaa}	Resident Exposure Duration - adult (yr)	20	20
ED_{0-2}	ResidentExposure Duration - age segment 0-2 (yr)	2	2
ED_{2-6}	Resident Exposure Duration - age segment 2-6 (yr)	4	4
ED_{6-16}	Resident Exposure Duration - age segment 6-16 (yr)	10	10
ED_{16-26}	Resident Exposure Duration - age segment 16-26 (yr)	10	10
ED_w; ED_{cw}	Worker Exposure Duration - (yr)	25	25
ET_{ra}; ET_{ress}	Resident Air Exposure Time (hours/day)	24	24
ET_{rs}	Resident Soil Exposure Time (hours/day)	24	24
ET_w	Worker Air Exposure Time (hr/hr)	8	8
ET_{ws}	Worker Soil Exposure Time (hours/day)	8	8
ET_{rw}; ET_{resw}	Resident Water Exposure Time (hours/day)	24	24

ET_{rwc}; ET_{reswc}	Resident Water Exposure Time - child (hours/event)	0.54	0.54
ET_{rwa}; ET_{reswa}	Resident Water Exposure Time – adult (hours/event)	0.71	0.71
ET_{0-2}	Exposure Time – age segment 0-2 (hours/event)	0.54	0.54
ET_{2-6}	Exposure Time – age segment 2-6 (hours/event)	0.54	0.54
ET_{6-16}	Exposure Time – age segment 6-16 (hours/event)	0.71	0.71
ET_{16-26}	Exposure Time – age segment 16-26 (hours/event)	0.71	0.71
EV_{reswc}	Events – child (events/day)	0.54	0.54
EV_{reswa}	Events – adult (events/day)	0.71	0.71
EV_{0-2}	Events - age segment 0-2 (events/day)	1	1
EV_{2-6}	Events - age segment 2-6 (events/day)	1	1
EV_{6-16}	Events - age segment 6-16 (events/day)	1	1
EV_{16-26}	Events - age segment 16-26 (events/day)	1	1
Soil to Groundwater Pathway Variables			
C_w	Target Soil Leachate Concentration (mg/l)	Site-specific	GW_1, GW_2 or GW_3
DF	Summers Dilution Factor (unitless) (< 0.5 acre source area)	1	20
I	Infiltration Rate (m/year)	0.18	0.1
L	source length parallel to ground water flow (m)	site-specific	SO, MO-1: 45 MO-2, MO-2: site-specific
i	hydraulic gradient (m/m)	site-specific	site-specific
K	aquifer hydraulic conductivity (m/year)	site-specific	site-specific
θ_w	water-filled soil porosity (L_{water}/L_{soil})	0.3	0.21
θ_a	air-filled soil porosity (L_{air}/L_{soil})	$= n-\theta_w$	0.15
n	total soil porosity(L_{pore}/L_{soil})	$= 1-(\rho_b/\rho_s)$	0.36
ρ_s	soil particle density (Kg/L)	2.65	2.65
ρ_b	dry soil bulk density (kg/L)	1.5	1.7
H'	Dimensionless Henry Law Constant (unitless)	analyte-specific	analyte-specific
K_d	soil-water partition coefficient (L/kg)	$= K_{oc}*f_{oc}$ for organics	$= K_{oc}*f_{oc}$ for organics
K_{oc}	soil organic carbon/water partition coefficient (L/kg)	analyte-specific	analyte-specific
f_{oc}	fraction organic carbon in soil (g/g)	0.002	0.006

d_a	aquifer thickness (m)	site-specific	site-specific
d_s	depth of source (m)	site-specific	site-specific
d	mixing zone depth (m)	site-specific	site-specific
Particulate Emission Factor Variables			
PEF_w	Particulate Emission Factor (m^3/kg)	1.36 E+09	5.06E+10 (Houston)
Q/C	Inverse of the Mean Concentration at the Center of a 0.5-Acre-Square Source (g/m^2-s per kg/m^3)	93.77	76.39
V	Fraction of Vegetative Cover (unitless)	0.5	0.5
U_m	Mean Annual Wind Speed (m/s)	4.69	3.49
U_t	Equivalent Threshold Value of Wind Speed at 7m (m/s)	11.32	11.32
F(x)	Function Dependent on U_m/U_t (unitless)	0.194	0.0103
A	Dispersion constant unitless	PEF and region-specific	13.65
A_s	Areal extent of the site or contamination (acres)	0.5 (range 0.5 to 500)	0.5
B	Dispersion constant unitless	PEF and region-specific	18.18
C	Dispersion constant unitless	PEF and region-specific	206.73
Volatilization Factor and Soil Saturation Variables			
VF_s	Volatilization Factor (m^3/kg)	Constituent-specific	Constituent-specific
Q/C_w	Inverse of the Mean Concentration at the Center of a 0.5-Acre-Square Source (g/m^2-s per kg/m^3)	68.81	76.39 (Houston)
D_A	Apparent Diffusivity (cm^2/s)	Constituent-specific	Constituent-specific
T	Exposure interval (s)	9.5E+08	9.5E+08
ρ_b	Dry soil bulk density (g/cm^3)	1.5	1.7
θ_a	Air-filled soil porosity (L_{air}/L_{soil}) ($n-\theta_w$)	0.28	0.15
n	Total soil porosity (L_{pore}/L_{soil}) ($1-(\rho_b/\rho_s)$)	0.43	0.36
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15	0.21
ρ_s	Soil particle density (g/cm^3)	2.65	2.65
S	Water Solubility Limit (mg/L)	Constituent-specific	Constituent-specific
D_{ia}	Diffusivity in air (cm^2/s)	Constituent-specific	Constituent-specific

H'	Dimensionless Henry's Law Constant	Constituent-specific	Constituent-specific
D_{iw}	Diffusivity in water (cm^2/s)	Constituent-specific	Constituent-specific
K_d	Soil-water partition coefficient (L/Kg) ($K_{oc} \times f_{oc}$)	Constituent-specific	Constituent-specific
K_{oc}	Soil organic carbon-water partition coefficient (L/Kg)	Constituent-specific	Constituent-specific
f_{oc}	Organic carbon content of soil (g/g)	0.006	0.006

A5.0 Summers Model ($DF_{Summers}$)

The mixing of unimpacted groundwater with impacted infiltration and the resultant concentrations in groundwater are estimated using the Summers Model. A default $DF_{Summers}$ of 20 is used for the SO, MO-1, and Appendix G MO-2 and is based on a source area of 0.5 acre (EPA Soil Screening Guidance, 1996). A site-specific $DF_{Summers}$ shall be calculated using the following model:

$DF_{Summers}$:

$$\frac{(Q_\rho + Q_a)}{Q_\rho} = \frac{C_l}{C_{si}}$$

where:

Parameter	Definition (units)	Input Value
C_{si}	constituent concentration in the groundwater (mg/l or g/m^3)	--
Q_ρ	volumetric flow rate of infiltration (soil pore water) from the AOI into the aquifer (m^3/day)	site-specific (refer below)
Q_a	volumetric flow rate of groundwater (m^3/day)	site-specific (refer below)
C_l	dissolved constituent concentration in the liquid phase (mg/l)	site-specific (refer below)

The volumetric flow rate of infiltration from the AOI into the aquifer:

Q_ρ (m^3/day): I x S_W x L

where:

Parameter	Definition (units)	Input Value
Q_ρ	volumetric flow rate of infiltration (soil pore water) from the AOI into the aquifer (m^3/day)	site-specific
I	infiltration rate (m/yr)	site-specific (0.1) [a]
S_W	source width perpendicular to groundwater flow (m)	site-specific
L	length of impacted area parallel to flow direction of aquifer (m)	site-specific

[a] *Soil Screening Guidance, User's Guide*, EPA 1996.

The volumetric flow rate of the groundwater is estimated as:

Q_a (m^3/day): D_v x S_d x S_W

where:

Parameter	Definition (units)	Input Value
Q_a	volumetric flow rate of groundwater (m^3/day)	--
D_v	groundwater darcy velocity in the aquifer (K x i) (m/yr)	site-specific (9.144 m/yr)
S_d	source thickness (i.e., the thickness of the impacted groundwater within the permeable zone) (m)	refer below
S_W	width of impacted area perpendicular to flow direction of aquifer (m)	site-specific

The aqueous-phase concentration (C_l) is estimated from the total soil concentration (C_{Tw}) as follows:

C_l (mg/l): $$C_{Tw}\left(\frac{[(\rho_w x \theta_w)+\rho_b]}{\rho_b K_d + \theta_w + (n-\theta_w) x H'}\right)$$

where:

Parameter	Definition (units)	Input Value
C_l	dissolved constituent concentration in the liquid phase (mg/l)	--
C_{Tw}	total soil concentration on a wet weight basis (mg/kg)	site-specific
ρ_w	density of water (g/cm^3)	1.0
ρ_b	dry bulk density of soil (g/cm^3)	site-specific (1.7) [a]
ρ_s	soil particle density (g/cm^3)	site-specific (2.65) [a]
n	total porosity of soil (L_{pore}/L_{soil})	site-specific (1 - ρ_b/ρ_s)
θ_w	water filled soil porosity (L_{water}/L_{soil})	site-specific (0.21) [a]
K_{oc}	soil organic carbon partition coefficient (cm^3/g)	chemical specific
f_{oc}	fractional organic carbon in soil = percent organic matter /174 (g/g) (ASTM 2974)	site-specific (0.006) [a]
K_d	soil water partition coefficient = K_{oc} x f_{oc} (cm^3/g)	chemical-specific
H'	Henry's Law Constant (dimensionless)	chemical-specific [b]

[a]LDEQ default value.
[b]H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-°K); and T = Absolute temperature of soil (°K) [273 + °C (25°C)].

A6.0 DOMENICO MODEL ($DF_{DOMENICO}$)

The reduction in COC concentrations in groundwater due to groundwater flow from the source area (POC) to the point of exposure (POE) is estimated using the Domenico model. Default Domenico dilution factors (DF) for MO-1 are presented in Section 4.2.3 of the main document. Domenico DF for UST sites and other small petroleum release sites are present in Appendix G Section G3.3. Before site-specific $DF_{Domenico}$ values are developed using the Domenico model equation presented below, the boundary conditions used to derive this equation shall be reviewed to determine if all of the assumptions are appropriate for the case being modeled (see reference) [a]. The Department will only allow the use of a $DF_{Domenico}$ that is based on the modeling of an infinite permeable zone to a distance of 2000 feet if constituent retardation and first-order degradation rate values are set to LDEQ default values (an equivalent situation was provided to typical UST sites). Otherwise, site-specific conditions (geological conditions) are to be taken into account in the model equation. If there is the potential for constituent migration to be influenced by pumping activities within the zone, a site-specific DF shall not be calculated using the Domenico model. The Submitter may develop a site-specific DF using an appropriate model under MO-3.

$DF_{Domenico}$ [a]:

$$\frac{C_{si}}{C_{(x)_i}} = 1/\left(\exp\left(\frac{x}{2\alpha_x}\left[1-\sqrt{1+\frac{4\lambda_i \alpha_x R_i}{v}}\right]\right)\left(erf\left[\frac{S_w}{4\sqrt{\alpha_y x}}\right]\right)\left(erf\left[\frac{S_d}{2\sqrt{\alpha_z x}}\right]\right)\right)$$

where:

Parameter	Definition	MO-1	MO-2 or MO-3
$C_{(x)i}$	concentration of constituent i in groundwater at distance *x* downstream of source (mg/L) or (mg/m^3)	--	--
C_{si}	concentration of constituent i in source zone (mg/L) or (mg/m^3)	--	--
S_w	source width perpendicular to groundwater flow (m)	45 [b]	SS [c]
D_v	groundwater Darcy velocity (K x i) (m/yr)	9.1 [d]	SS [c] (9.1)
n	total soil porosity (L_{pore}/L_{soil}))	0.36 [d]	SS [c] ($1-\rho_b/\rho_s$)
λ_i	first-order degradation rate for constituent i (day^{-1})	0 [d]	SS [c,e] (0)
R_i	constituent retardation factor (dimensionless)	1 [d]	SS [c,e] (1)
i	hydraulic gradient (dimensionless)	--	SS [c]

v	groundwater seepage velocity (m/yr)	25.4	(K x i)/n
x	distance downgradient from source (m)	SS [c]	SS [c]
K	hydraulic conductivity (m/yr)		SS [c]
α_x	longitudinal groundwater dispersivity (m)	(x * 0.1)	(x * 0.1)
α_y	transverse groundwater dispersivity (m)	(α_x / 3)	(α_x / 3)
α_z	vertical groundwater dispersivity (m)	(α_x / 20) or L/200	(α_x / 20) or L/200
erf	error function; $erf\chi = \frac{2}{\sqrt{\pi}}\int_o^{\chi} e^{-t^2}\,dt$	refer below	refer below
S_d	source thickness (i.e., the thickness of the impacted groundwater within the permeable zone) (m)	SS [c,f]	SS [c,f]
ρ_b	dry soil bulk density (g/cm^3)	1.7 [d]	SS (1.7) [d]
ρ_s	soil partical density (g/cm^3)	2.65 [d]	SS (2.65) [d]

[a]Domenico, P.A. and F.W. Schwartz, 1990. *Physical and Chemical Hydrogeology*, John Wiley and Sons, New York, N.Y.
[b]Based on a 0.5 acre source.
[c]Site-specific.
[d]LDEQ default value.
[e]Degradation and/or retardation shall only be included in the model when site-specific quantitative data documents occurrence and the DF is being generated for a MNA program. Derivation of constants for these processes shall be included with the model input data. Degradation and retardation data are by definition monitored natural attenuation processes. Therefore, literature values for retardation and degradation are not acceptable under the RECAP.
[f] Estimation of S_d using Method 1 or 2 as presented below.

The **S_d** is defined as the thickness of the contaminated groundwater within the permeable zone. Refer to Figure 3 of the main document for an illustration of S_d.

For the purpose of developing a $DF_{Domenico}$ for GW_2, LDEQ requires that the S_d be estimated using Method 1 or 2. If the estimated S_d value exceeds the aquifer thickness, S_d should be set to the thickness of the aquifer.

Method 1: Sum of advective and dispersive depths:

$S_d = h_{adv} + h_{disp}$

where:

Parameter	Definition (units)	Input Value
S_d	source thickness (i.e., the thickness of the impacted groundwater within the permeable zone) (m)	--
h_{adv}	advective component of the plume depth (m)	site-specific
h_{disp}	dispersive component of the plume depth (m)	site-specific

$h_{adv} = B[1-\exp((-I \times L)/(B \times D_v))]$

where:

Parameter	Definition (units)	Input Value (Default Value)
h_{adv}	advective component of the plume depth (m)	site-specific
I	infiltration rate (m/yr)	site-specific (0.1) [a]
D_v	Darcy groundwater velocity (K x i) (m/yr)	site-specific (9.144) [a]
B	thickness of the shallow water bearing zone (m)	site-specific (< 6.1) [a]
L	length of the source parallel to the groundwater flow at the water table (m)	site-specific

[a]LDEQ default value.

$h_{disp} = (2 \times \alpha_z \times L)^{1/2}$

where:

Parameter	Definition (units)	MO-2 Input Value (Default Value)
h_{disp}	dispersive component of the plume depth (m)	site-specific
α_z	vertical groundwater dispersivity (m)	site-specific (α_x/20) or (L/200) [a]
L	length of the source parallel to the groundwater flow at the water table (m)	site-specific

Method 2: Thickness of the aquifer

The thickness of the impacted permeable zone shall be used as the S_d if the thickness of the groundwater plume is not known.

SOLUTION TO THE ERROR FUNCTION

χ	erf χ
0.00	0.000 000
0.05	0.056 372
0.10	0.112 463
0.15	0.167 996
0.20	0.222 703
0.25	0.276 326
0.30	0.328 627
0.35	0.379 382
0.40	0.428 392
0.45	0.475 482
0.50	0.520 500
0.55	0.563 323
0.60	0.603 856
0.65	0.642 029
0.70	0.677 801
0.75	0.711 156
0.80	0.742 101
0.85	0.770 668
0.90	0.796 908
0.95	0.820 891
1.00	0.842 701

χ	erfχ
1.1	0.880 205
1.2	0.910 314
1.3	0.934 008
1.4	0.952 285
1.5	0.966 105
1.6	0.976 348
1.7	0.983 790
1.8	0.989 091
1.9	0.992 790
2.0	0.995 322
2.2	0.998 137
2.4	0.999 311
2.6	0.999 764
2.8	0.999 925
3.0	0.999 978
3.2	0.999 994
3.4	0.999 998
3.6	1.000 000
3.8	1.000 000
≥ 4.0	1.000 000

A7.0 DOCUMENTATION FOR SS AND MO-1 RS

The $Soil_{ssni}$, $Soil_{ssi}$, $Soil_{ni}$, $Soil_{i}$, $Soil_{SSGW}$, $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{sat}$, GW_{SS}, GW_{1}, and GW_{2} where applicable, were calculated in accordance with this appendix. The toxicity values were identified in accordance with Section 2.4 of the main document (refer to Table A-1). The physical/chemical properties data were obtained from EPA Mid-Atlantic Risk Assessment Screening Levels Tables (refer to Table A-2). The SS and RS for total petroleum hydrocarbon components are based on the toxicity values and physical/chemical parameters presented in Appendix D.

The EPA equations and default inputs for $Soil_{ssni}$ and $Soil_{ni}$ (Resident); $Soil_{ssi}$ and $Soil_{i}$ (Composite Worker); $Soil_{SSGW}$, $Soil_{GW1}$ and $Soil_{GW2}$ (Soil to Groundwater) $Soil_{sat}$ (Soil Saturation Limit); GW_{SS}, GW_{1}, and GW_{2} (Tap Water); VC_{ni} (ES vapor concentration for nonindustrial land use); VC_{i} (ES vapor concentration or industrial/commercial land use) were obtained from the EPA Mid-Atlantic Risk Assessment Screening Level Table User's Guide (June 2017). The EPA Mid-Atlantic Risk Assessment Screening Level Calculator (2017) was used to calculate the $Soil_{ssni}$, $Soil_{ssi}$, $Soil_{ni}$, $Soil_{i}$, $Soil_{SSGW}$, $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{sat}$, GW_{SS}, GW_{1}, and GW_{2} presented in Text Tables 1, 2, and 3; and Appendix G Tables G-1 though G-8 (except for those standards represented by a state or federal regulatory value).

The $Soil_{ni}$ and $Soil_{i}$ for arsenic and thallium are state background levels based on the mean plus one standard deviation of the state-wide soil data presented in Smith, D.B., Cannon, W.F., Woodruff, L.G., Solano, Federico, Kilburn, J.E., and Fey, D.L. 2013. *Geochemical and mineralogical data for soils of the Conterminous United States: U.S. Geological Survey Data Series 801*. The $Soil_{ni}$ and $Soil_{i}$ for lead are based on the EPA's IEUBK and adult lead model and EPA recommended input values, respectively, in conjunction with EPA recommended input values. The $Soil_{sat}$ for the petroleum fractions were obtained from the literature, refer to Appendix D for further details. The soil ceiling value was obtained from *EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites* User's Guide.

The GW_{1} and GW_{2} values, where available, are the SDWA MCL, EPA action level, or EPA drinking water advisory level. The GW_{3} RS where available were obtained from LAC 33:IX.1113, Table 1 (July 2017). The GW_{3} equations and input parameters were obtained from *Standard Operating Procedure for Human Health Criteria Calculations for Toxic Substance in Louisiana*, Water Permits Division Office of Environmental Services, LDEQ December 2016 and are consistent with LAC 33:IX.1113, Table 1. The GW_{3} and $Soil_{GW3}$ were calculated using the 2003 LDEQ RECAP spreadsheet.

The Reporting Limits used as SS and RS are presented in Table A-3. The BCF values used in the calculation of the GW_{3} RS are presented in Table A-4.