Appendix 4D
Volatilisation modelling

1.1 Overview

Modelling the migration of volatiles from contaminated soil and groundwater into outdoor and indoor air is an important component in deriving Tier 1 Acceptance Criteria for soil and groundwater.

For the purposes of this module it is necessary to predict contaminant concentrations in air within the breathing zone of the nominated receptors for the following scenarios;

- Soil to indoor air
- Soil to outdoor air
- Groundwater to indoor air
- Groundwater to outdoor air.

Some of the key mechanisms and processes considered in modelling the transport of volatile components are outlined as follows:

- **Diffusion through soil air (and, to a lesser extent, soil water)**

Diffusion has been assumed to be the dominant means of transport through the soil column.

- **Advective transport through the soil column**

  Advective transport has been shown to be important, particularly for the intrusion of vapours into basement areas where heating or other processes establish a pressure differential between the soil and the building. Advective transport is likely to be most important where contaminated soils are located within 1 metre of the building foundations. Advective transport has been considered in modelling emissions from surface soils (<1 metre) to indoor air.

- **Diffusion and advective transport through building foundations**

  As discussed above, advective transport is assumed to be negligible except where contaminated soils are located within 1 metre of the building foundation. Diffusion through the building foundations can be a dominant resistance component in many scenarios. For the purposes of modelling, slab on ground construction has been assumed for both commercial and residential buildings. Preliminary estimates indicate that contaminant concentration in indoor air in houses constructed on stumps with sub-floor ventilation, are lower than those for slab on ground construction, i.e. use of the slab on ground construction is conservative.

- **Depletion of contaminant source with time through volatilisation, leaching and biodegradation**

  Biodegradation of the contaminant source has been conservatively neglected due to a lack of reliable quantitative data, however the Jury based model, used to predict emission from contaminated soil, can incorporate first order biodegradation of contaminants. Source depletion through volatilisation has been considered, however losses due to leaching have been set to zero. This represents a conservative assumption in the case of diffusion to outdoor air, however leaching is expected to be negligible beneath buildings or paved areas.

A constant source has been assumed in modelling volatilisation from groundwater to indoor or outdoor air.

- **Biodegradation of the vapour plume**

  Biodegradation of the vapour plume has been conservatively neglected at this stage due to the lack of reliable quantitative information. Current research in the United States may provide information allowing inclusion of this process in the future.

- **Dilution and dispersion of contaminants in the receiving air environment**

  Simple box dilution model, assuming contaminants are fully mixed within the box, have been assumed for both indoor and outdoor air.

- **Diffusion through the air boundary layer in transport to outdoor air**

  The volatilisation of some contaminants from surface soils to outdoor air can be influenced by the resistance to transport through the air surface boundary layer. The boundary layer resistance has been conservatively neglected in deriving Tier 1 criteria for soils. This approach is consistent with that used in RBCA[1], however, the boundary layer resistance is readily incorporated in the Jury based models. The air boundary layer resistance is expected to be negligible compared to the soil column resistance for all but the very surface layers of soil.

Each of the volatilisation models used may be considered to be comprised of the following units or modules:

- Equilibrium partitioning

  Predicting soil gas concentrations at the source, based on measured soil or groundwater concentrations

- Diffusion transport

  Predicting the flux of contaminants through the soil column and concrete slab foundation (if appropriate) based on gas and liquid phase diffusion and advective transport (where appropriate) given the soil gas concentration at the source layer (and liquid phase convection in the case of the Jury model);

- Dilution

  Predicting the indoor or outdoor air concentrations resulting from a given flux, based on simple box models.

1.2 Volatilisation factor

The Volatilisation Factor is used to relate the indoor and outdoor air concentrations to the measured soil concentrations. Some volatilisation models are configured to return a Volatilisation Factor. The Volatilisation Factor is defined as follows:

$$VF = \frac{C_{AIR}}{C_{SOIL}} \quad \textbf{for soil contamination} \qquad \text{(D1)}$$

[1] ASTM (1995) "Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites", Designation: E 1739-95

$$VF = \frac{C_{AIR}}{C_{GW}} \quad \textbf{for groundwater contamination} \qquad \text{(D2)}$$

where:

VF = Volatilisation factor for soil or groundwater

C_{AIR} = Concentration in the air for indoors or outdoors (mg/m^3)

C_{SOIL} = Concentration of contaminant in soil (mg/kg)

C_{GW} = Concentration of contaminant in groundwater (mg/L)

1.3 Soil volatilisation model

1.3.1 Summary

Two models have been considered as the basis for the modelling the emission of volatile contaminants from soil. The two models are summarised as follows:

- **Modified Jury behaviour assessment model (BAM)**

  Jury et al (1983) developed a model for volatilisation of contaminants from surface soils, accounting for the boundary layer resistance associated with transport into the bulk air. The original Jury model is limited in that it does not account for diffusion from sub-surface soils, or transport into indoor air. Modification of the Jury model involved substituting boundary condition for the governing differential equation describing the boundary layer resistance, for one incorporating the resistance to transport through the overlying soil, in the case of sub-surface soils, and transport through the building foundations for indoor air. This does not alter the form of the Jury solution. A disadvantage of the Jury model is the complexity of the equations and the inability to account for advective transport in the vapour phase.

- **Modified Johnson and Ettinger model**

  Johnson and Ettinger (1991) developed a model for estimating indoor air concentrations resulting from contaminated soil. The non-depleting (infinite) source model developed by Johnson and Ettinger was used in the RBCA protocol. The Johnson and Ettinger model incorporates a simplification of the conceptual model that allows solution of a depleting source model. This model was modified to consider slab on ground construction (rather than a basement), and allow use of the same model to assess transport to outdoor air. The modified Johnson and Ettinger model is mathematically simpler than the Jury model but incorporates a simplification in the conceptual model and therefore the criteria developed using the modified Johnson and Ettinger model are lower than those developed using the Jury model by a factor of less than 2.

The Tier 1 soil acceptance criteria have been determined using the Jury model where diffusion is limiting. Where advective transport is important (soils <1 metre) the Johnson and Ettinger model has been used. In practice consideration of advective transport results in more rapid depletion of the contaminated layer with a higher peak indoor air concentration. The long term (20-30 years) average concentration in indoor or outdoor air does not change significantly as in most cases the soil layer fully depletes even when diffusion only transport is considered.

The Johnson and Ettinger model has been used to estimate volatile emissions from groundwater.

A limitation of the Jury model is the assumption of linear, single component phase partitioning. This is the most common phase partitioning approach used, however it overestimates the concentration in the vapour phase where separate phase hydrocarbons begin to form, thus overestimating the concentration in indoor or outdoor air. The Johnson and Ettinger model is not necessarily subject to the same limitation as it uses as a starting point the soil gas concentration. However, the Johnson and Ettinger model must be used in conjunction with a phase partitioning relationship and of these the linear relationship discussed above is most common[2]. The Johnson and Ettinger model can be used with alternative phase partitioning relationships if necessary.

The Jury model (Jury et al, 1983) is based on a solution to the following differential equation (mass balance):

$$\frac{\partial C_T}{\partial t} = D_E\left(\frac{\partial^2 C_T}{\partial z^2}\right) - V_E\left(\frac{\partial C_T}{\partial z}\right) - \mu C_T \qquad \text{(D3)}$$

The Jury model is configured to account for:

- volatilisation from a uniformly contaminated layer of soil, starting at the surface and extending to a depth of L
- diffusion of contaminants through the soil
- transport of contaminants through the surface boundary layer (a boundary condition for solution of the differential equation)
- advective transport of contaminants in soil moisture (either upward or downward).

In order to generalise the Jury model to model the emission of volatiles from a uniformly contaminated layer of soil some depth below the surface and to account for transport to indoor air, the boundary layer resistance term (He) in the solution to the Jury model was redefined to reflect the resistance to transport provided by either;

- overlying "clean" soil in the case of transport to outdoor air, assuming the resistance provided by the layer of soil exceeds that provided by the air boundary layer
- overlying "clean" soil and the concrete slab foundation for a building in the case of transport to indoor air.

Given that in each case the resistance term (H_e) can be defined in terms of a constant or combination of constants (i.e. independent of time and depth), the form of the Jury solution remains unchanged. This approach incorporates a simplifying assumption in that the overlying soil is treated as a simple resistance rather than as a continuation of the contaminated media. This approach neglects the impact of attenuation in the overlying soils but does facilitate use of the simpler solution to the differential equation.

The resistance terms describing the impact of the overlying soil layers and the concrete slab foundation are based on Johnson and Ettinger (1991) as used in RBCA.

The Johnson and Ettinger (1991) depleting source model is based on a simplifying assumption of sequential removal of contaminants from the upper surface of the contaminated layer, such that the, say, the initial step change in soil concentration assumed in the case of a buried layer of contaminated

[2] A linear relationship is most commonly assumed because it is simple and mathematically convenient rather than because it is the best approach under all circumstances.

soil is retain throughout, with only the depth to the upper surface of the contamination and the thickness of the contaminated layer varying. This simplification results in a less complex solution to the differential equation, however the resultant model slightly overestimates the flux of contaminants relative to the Jury model predictions.

The equations for both the modified Jury and modified Johnson models are presented in Section 3.5.

1.3.2 Equilibrium model

A simple three phase linear partitioning model has been adopted, based on the assumption that at any point time within the system, an equilibrium is established between contaminant concentrations within each of the phases; adsorbed, dissolved and soil vapour. Adsorption of contaminants is assumed to be governed by a linear organic carbon relationship, which is found to hold for most moist soils. The vapour/dissolved phase equilibrium is assumed to be governed by Henry's Law. This approach is consistent with that used by most volatilisation models and is expected to overestimate volatilisation when separate phase hydrocarbons form.

1.3.3 Soil to indoor air

Transport of contaminants from soil to indoor air is modelled on the assumption of diffusive transport, based on the Millington-Quirk model to account for the tortuosity of the diffusion path (refer equations D10 and D11). The Millington-Quirk model is adopted in the derivation of both the Jury and Johnson and Ettinger models. The Millington-Quirk model is used to determine an effective diffusivity governing the movement of contaminants in the sub-surface.

Diffusion through concrete foundations is assumed to occur via cracks in the slab. The movement of volatiles through concrete slabs is not well understood, however the approach adopted by Johnson and Ettinger (1991) has been used in this instance. Transport through the concrete slab is assumed to occur by diffusion through cracks, which are themselves partially filled with particulate matter. Diffusion through the cracks is modelled in a manner consistent with diffusion through soils, with the exception that the diffusion area is adjusted to account for the area of the crack.

1.3.4 Soil to outdoor air

Transport of contaminants from soil into outdoor air is again assumed to occur as a result of diffusion. In this case advective transport in both the gas and liquid phase have been neglected.

Diffusive transport is modelled using the Millington-Quirk model as outlined above. Any air boundary layer resistance is assumed to be negligible compared to the resistance to diffusion through the soil column.

1.3.5 Equations

Refer Jury et al, 1983

For all modelling equations, definitions of parameters used and adopted values are presented in Section 8.

Equilibrium

C_T = Total Concentration of Contaminant (M/L^3)

$= R_S C_S = R_L C_L = R_G C_G$ (D4)

$= r_S C_S + qC_L + aC_G$ (D5)

r_S = Bulk density of soil (M/L^3)

q = Water volume fraction

a = Air volume fraction

C_S = Concentration of contaminant in the solid phase (M/M)

C_L = Concentration of contaminant in the liquid phase (M/L^3)

C_G = Concentration of contaminant in the vapour phase (M/L^3)

$$R_S = \rho_S + \frac{\theta}{K_D} + \frac{aK_H}{K_D}$$

= Solid phase equilibrium partitioning parameter (unitless, refer D4) (D6)

$R_L = r_s K_D + q + aK_H$ (D7)

= Liquid phase equilibrium partitioning parameters (unitless, refer D4)

$$R_G = \frac{\rho_S K_D}{K_H} + \frac{\theta}{K_H} + a \quad \text{(D8)}$$

= Gas phase equilibrium partitioning parameter (unitless, refer D4)

K_H = Henry's Constant (unitless) (D9)

$K_D = F_{OC} * K_{OC}$

F_{OC} = Fraction of Organic Carbon

K_{OC} = Organic Carbon Adsorption Coefficient

Diffusive Transport

D_E = Retarded Diffusion Coefficient based on total soil concentration (L^2/t) (D10)

$$= \frac{D_G}{R_G} + \frac{D_L}{R_L}$$

$$D_G = D_G^{air}\left(\frac{a^{10/3}}{\phi^2}\right) \quad \text{(D11)}$$

$$D_L = D_L^{wat}\left(\frac{\theta^{10/3}}{\phi^2}\right) \quad \text{(D12)}$$

f = Total porosity = a + q

Z = Distance from top of contamination layer (down is +ve)

t = Time

Co = Initial C_T (t = 0)

H_E = Boundary Condition term

$$= \frac{1}{R_G\left(\frac{L_S}{D_S^{eff}} + \frac{L_{crack}}{D_{crack}\eta}\right)}$$ for indoor air calculation (concrete slab). (D13)

$$= \frac{1}{R_G\left(\frac{L_S}{D_S^{eff}}\right)}$$ for outdoor air calculation (no concrete slab). (D14)

L_S = depth of soil above contamination layer (L)

D_S^{eff} = effective diffusion coefficient of overlay soil (L^2/t)

L_{crack} = thickness of foundation or concrete paving (L)

D_{crack} = effective diffusion coefficient of soil in foundation cracks (L^2/t)

h = area of cracks / area of foundation

V_E = effective solute advective velocity (L/t) (D15)

$$= \frac{J_W}{R_L}$$

J_W = water flux (M/L^2t)

L = Contamination Layer Thickness (L)

m = Degradation Rate (1/t)

J_S = Contamination Flux (M/L^2t)

Diffusive Flux

$$J_S(Z,t) = \frac{1}{2} CoH_E.\exp(-mt).\text{erfc}\left(\frac{Z - V_E t}{\sqrt{4D_E t}}\right)$$

$$-\frac{1}{2} CoH_E.\exp(-mt).\text{erfc}\left(\frac{Z - L - V_E t}{\sqrt{4D_E t}}\right)$$

$$+\frac{1}{2} Co(H_E+V_E).\exp\left(\frac{V_E Z}{D_E} - \mu t\right)\text{erfc}\left(\frac{Z + V_E t}{\sqrt{4D_E t}}\right)$$

$$-\frac{1}{2} Co(H_E+V_E).\exp\left(\frac{V_E Z}{D_E} - \mu t\right)\text{erfc}\left(\frac{Z + L + V_E t}{\sqrt{4D_E t}}\right)$$

$$+\frac{1}{2} Co(2H_E+V_E).\exp\left(\frac{H_E(H_E + V_E)t + (H_E + V_E)Z + H_E L}{D_E} - \mu t\right)$$

$$* \text{erfc}\left(\frac{Z + L + (2H_E + V_E)t}{\sqrt{4D_E t}}\right)$$

$$-\frac{1}{2} Co(2H_E+V_E).\exp\left(\frac{H_E(H_E + V_E)t + (H_E + V_E)Z}{D_E} - \mu t\right)\text{erfc}\left(\frac{Z + (2H_E + V_E)t}{\sqrt{4D_E t}}\right)$$

(D16)

Surface Soil to Outdoor Air (Special Case)

$$VF_{ss}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right]=\frac{2W\rho_s}{U_{air}\delta_{air}}\sqrt{\frac{D_s^{eff}H}{\pi(\sigma_{ws}+k_s\rho_s+H\sigma_{as})\tau}}\times10^3\frac{cm^3.kg}{m^3.g} \quad (D17)$$

or $$VF_{ss}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right]=\frac{W\rho_s d}{U_{air}\delta_{air}\tau}\times10^3\frac{cm^3.kg}{m^3.g}$$ whichever is less. (D18)

1.3.6 Surface soils

The volatilisation models presented to date are based on the assumption of diffusive transport only, i.e. no advective transport. However a pressure differential between indoor air and outdoor air (and hence soil gas) can be established by heating and other processes. Such pressure differences can induce advective transport of contaminants through soil and into indoor air. This is expected to be an important mechanism for surface soils (i.e. depths <1 metre).

The original Johnson and Ettinger model accounted for advective transfer. The ASTM RBCA guidance presents a simplified version of the equation which includes an assumption of no advective transport. The original diffusion/advective transport, depleting source form of the Johnson and Ettinger model has been used to estimate a volatilisation factor for surface soils to indoor air.

Theoretical work on surficial contaminated soils (Ferguson et al, 1995) suggest that pressure-driven flow is likely to dominate in winter. A pressure difference of 3.5 Pa, between indoor and outdoor air, in winter was used, which is consistent with UK measurements (made by the Building Research Establishment). This is also the default value used by Nazaroff et al (1985) for single-storey North American houses with basements.

The Johnson and Ettinger equations are composed of two parts: a depleting layer equation and a mass balance. When the volatilisation factor based on transport from the depleting layer becomes greater than the volatilisation factor based on a simple mass balance, then it is assumed that the contaminated layer is fully depleted.

Mass depleting equation:

$$VF_{sesp}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right]=\frac{\rho_s}{\tau ER.L_B}\left[\sqrt{\gamma^2+2\psi\tau}-\gamma\right]\times10^3\frac{cm^3.kg}{m^3.g} \quad (D19)$$

where: $$\gamma=\frac{D_S^{eff}A_B}{Q_{soil}}\left[1-\exp\left(\frac{-Q_{soil.}L_{crack}}{D_{crack.}A_B\eta}\right)\right] \quad (D20)$$

$$\psi=\frac{D_s^{eff}H}{\left[\sigma_{ws}+k_s\rho_s+H\sigma_{as}\right]} \quad (D21)$$

or mass balance for depleted layer (which ever is less).

$$VF_{sesp}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right]=\frac{\rho_s\Delta H_c}{\tau ER.L_B}\times10^3\frac{cm^3.kg}{m^3.g} \quad (D22)$$

Most of the parameters used above are defined in Section 8. Other parameters used include:

- A_B: surface area
- Q_{soil}: advective emission rate.

The surface area of the building foundation area has been set at 200 m^2 for residential buildings and 400 m^2 for commercial buildings. The dimensions of the buildings are important when considering pressure induced transfer. The assumed dimensions of the residential and commercial buildings are 16.67 m x 12 m and 20 m x 20 m respectively.

Q_{soil} has been estimated by Nazaroff by the following equations:

$$Q_{soil} = \frac{2\pi \Delta P k_v X_{crack}}{\mu_v \ln\left(2Z_{crack} / r_{crack}\right)} \quad \text{(D23)}$$

and $$r_{crack} = \frac{\eta A_B}{X_{crack}} \quad \text{(D24)}$$

where:

DP=Pressure difference (35 g/cm.s^2)

k_v=permeability of soil (cm^2)

X_{crack}=perimeter of floor area (cm)

m_v=vapour phase viscosity (1.8 x 10^{-4} g/cm.s)

Z_{crack}=depth to contamination (foundation thickness) (cm)

h=areal fraction of cracks in foundation (0.01)

A_B=Total area of infiltration (cm^2)

r_{crack}=radius of crack in foundation (cm)

1.4 Groundwater volatilisation model

1.4.1 Overview

Transport of volatile contaminants from contaminated groundwater to indoor or outdoor air may be modelled using a pseudo steady state approach provided the groundwater concentration remains constant with time. Assumption of pseudo steady state conditions greatly simplifies the governing differential equations and the resultant expressions for contaminant flux at the soil surface.

For the purposes of deriving Tier 1 Groundwater Acceptance Criteria pseudo steady state conditions are assumed to hold and therefore the solutions to the steady state model presented in the RBCA protocol, based on Johnson and Ettinger (1991), have been adopted.

Assumption of constant contaminant concentrations in groundwater requires that contaminants lost through volatilisation and other mechanisms (e.g. biodegradation) are replaced by the ongoing contamination of groundwater by a source e.g. contaminated soil. More detailed, site-specific modelling is required to account for variations in groundwater concentrations with time.

Where volatilisation from soil has been modelled on the basis of uniform soil conditions or properties, the adopted model for volatilisation from groundwater accounts for the increased moisture content and reduced air filled porosity associated with the capillary zone immediately above the groundwater.

1.4.2 Groundwater to indoor air

The volatilisation of contaminants from groundwater to outdoor air, as described by the Volatilisation Factor, may be estimated using the following expression:

(Refer - Johnson and Ettinger, 1991)

$$VF_{wesp}\left[\frac{(mg/m^3-air)}{(mg/L-H_2O)}\right]=\frac{H\left[\frac{D_{ws}^{eff}/L_{GW}}{ER.L_B}\right]}{1+\left[\frac{D_{ws}^{eff}/L_{GW}}{ER.L_B}\right]+\left[\frac{D_{ws}^{eff}/L_{GW}}{(D_{crack}^{eff}/L_{crack})\eta}\right]}\times 10^3\,\frac{L}{m^3}$$

(D25)

1.4.3 Groundwater to outdoor air

The volatilisation of contaminants from groundwater to outdoor air, as described by the Volatilisation Factor may be estimated using the following expression:

(Refer - USEPA, 1988)

$$VF_{amb}\left[\frac{(mg/m^3-air)}{(mg/L-H_2O)}\right]=\frac{H}{1+\left[\frac{U_{air}\delta_{air}L_{GW}}{WD_{ws}^{eff}}\right]}\times 10^3\,\frac{L}{m^3}$$

(D26)

1.4.4 Effective diffusion coefficients

The effective diffusion coefficients, or the effective diffusivity, of the soil profile including the capillary zone, must be determined for use in the equations presented above for volatilisation from groundwater.

(Refer - Johnson and Ettinger, 1991)

$$D_s^{eff}\left[\frac{cm^2}{s}\right]=D^{air}\frac{\sigma_{as}^{3.33}}{\sigma_T^2}+D^{wat}\frac{1}{H}\frac{\sigma_{ws}^{3.33}}{\sigma_T^2}$$

Effective diffusion coefficient through soil (D27)

$$D_{cap}^{eff}\left[\frac{cm^2}{s}\right]=D^{air}\frac{\sigma_{acap}^{3.33}}{\sigma_T^2}+D^{wat}\frac{1}{H}\frac{\sigma_{wcap}^{3.33}}{\sigma_T^2}$$

Effective diffusion coefficient through capillary fringe (D28)

$$D_{ws}^{eff}\left[\frac{cm^2}{s}\right]=(h_{cap}+h_v)\left[\frac{h_{cap}}{D_{cap}^{eff}}+\frac{h_v}{D_s^{eff}}\right]^{-1}$$

Effective diffusion coefficient between groundwater and soil surface (D29)

$$D_{crack}^{eff}\left[\frac{cm^2}{s}\right]=D^{air}\frac{\sigma_{acrack}^{3.33}}{\sigma_{Tcrack}^2}+D^{wat}\frac{1}{H}\frac{\sigma_{wcrack}^{3.33}}{\sigma_{Tcrack}^2}$$

Effective diffusion coefficient through foundation cracks (D30)

1.5 Outdoor air dilution model

The modified Jury model for volatilisation from contaminated soil can be used to estimate the flux of contaminants to indoor or outdoor air. It is necessary to link estimates of the flux with a dilution model to give the indoor and outdoor air concentrations. A simple box model was used for both indoor and outdoor air concentrations, as follows:

$$C_{OUTDOOR} = \frac{J \times W}{U_{air} \times \delta_{air}} \quad \text{(D31)}$$

where: J = Flux of Contaminant into Outdoor Air

W = Width of site (parallel to wind direction)

U_{air} = Wind Speed

d_{air} = Ambient air mixing zone height

$$C_{INDOOR} = \frac{J}{ER \times L_B} \quad \text{(D32)}$$

where: J = Flux of contaminant into building

ER = Air exchange rate of building

L_B = Enclosed space volume / Infiltration area ratio

The expressions presented in Section 5 for the volatilisation factors, describing the volatilisation of contaminants from groundwater, already incorporate the simple box models presented above.

1.6 Average concentration

Exposure estimates used in risk assessment for chronic (including carcinogenic) health effects are based on an estimate of the long term average indoor and outdoor air concentrations. The modified Jury model predicts contaminant fluxes (and therefore air concentrations) that vary with time. For the modified Jury model the flux is calculated as shown in Section 3.5 with the appropriate dilution factor (Eq. D31, D32) applied to calculate the instantaneous concentration of the air. The average concentration is calculated as follows:

$$\overline{C_{AIR}} = \frac{\int_0^{\tau} C_{AIR}\, dt}{\tau} \quad \text{(D33)}$$

where t = averaging time

= Exposure duration for carcinogenic contaminants (e.g. 20 years for commercial use, 30 years for residential use)

= 7 years for Non-Carcinogenic Contaminants (refer to Module 4).

The averaging time, t, is also used in the volatilisation factor calculation for volatilisation of contaminants from surface soils to ambient air. Due to the form of the Jury solution (D16) a numerical procedure (Simpson's Rule) for integrations and averaging has been used.

1.7 Modified Johnson and Ettinger model

1.7.1 Overview

A modified version of the Johnson and Ettinger (1991) model may also be used to estimate the volatilisation of contaminants from soil. Modifications to the Johnson and Ettinger model considered included neglecting advective transport of vapours, assumption of no basement and configuring model for transport to outdoor, as well as indoor, air. The modified version of Johnson and Ettinger model, including the dilution component is presented in the following sections.

The modified Johnson and Ettinger model is presented here for information and comparison with the modified Jury model. It represents a simpler calculation procedure which results in slightly more conservative (stringent) acceptance criteria.

1.7.2 Soil to indoor air

Mass-depleting Equation:

$$\mathrm{VF_{sesp}}\left[\frac{(\mathrm{mg/m^3-air})}{(\mathrm{mg/kg-soil})}\right]=\frac{\rho_s \mathrm{L_T^o}}{\tau \mathrm{ER.L_B}}\left[\sqrt{\beta^2+2\chi\tau}-\beta\right]\times 10^3\,\frac{\mathrm{cm^3.kg}}{\mathrm{m^3.g}} \qquad \text{(D34)}$$

where: $\beta=\dfrac{\mathrm{D_s^{eff}L_{crack}}}{\mathrm{D_{crack}}\eta\mathrm{L_T^o}}+1$ (D35)

$$\chi=\frac{\mathrm{D_s^{eff}H}}{(\mathrm{L_T^o})^2\left[\sigma_{ws}+\mathrm{k_s}\rho_s+\mathrm{H}\sigma_{as}\right]} \qquad \text{(D36)}$$

or mass balance for depleted layer (which ever is less).

$$\mathrm{VF_{sesp}}\left[\frac{(\mathrm{mg/m^3-air})}{(\mathrm{mg/kg-soil})}\right]=\frac{\rho_s \Delta \mathrm{H_c}}{\tau \mathrm{ER.L_B}}\times 10^3\,\frac{\mathrm{cm^3.kg}}{\mathrm{m^3.g}} \qquad \text{(D37)}$$

1.7.3 Soil to outdoor air

For transport from soil to outdoor air L_{crack} is assumed to equal 0 (therefore $\beta = 1$) and the dilution component of the expression is replaced with that appropriate to dilution in outdoor air.

$$\mathrm{VF_{samb}}\left[\frac{(\mathrm{mg/m^3-air})}{(\mathrm{mg/kg-soil})}\right]=\frac{\mathrm{W}\rho_s}{\mathrm{U_{air}}\delta_{air}\tau}\left[\sqrt{(\mathrm{L_T^o})^2+\frac{2\mathrm{D_s^{eff}}\tau\mathrm{H}}{\left[\sigma_{ws}+\mathrm{k_s}\rho_s+\mathrm{H}\sigma_{as}\right]}}-\mathrm{L_T^o}\right]\times 10^3\,\frac{\mathrm{cm^3.kg}}{\mathrm{m^3.g}} \qquad \text{(D38)}$$

or

$$\mathrm{VF_{samb}}\left[\frac{(\mathrm{mg/m^3-air})}{(\mathrm{mg/kg-soil})}\right]=\frac{\mathrm{W}\rho_s \mathrm{d}}{\mathrm{U_{air}}\delta_{air}\tau}\times 10^3\,\frac{\mathrm{cm^3.kg}}{\mathrm{m^3.g}}$$

whichever is less. (D39)

1.8 Model parameters

The key input parameters for volatilisation from both soil and groundwater to indoor and outdoor air are presented in Tables 4Da and 4Db.

Table 4Da Summary of model parameters

Parameter	Definition	Adopted Value
r_s	bulk density of soil	soil specific
q_{as}, a	air porosity of soil	soil specific
q_{ws}, q	water porosity of soil	soil specific
q_T, f	total porosity	soil specific
q_{acap}	air porosity of soil in capillary fringe	soil specific
q_{wcap}	water porosity of soil in capillary fringe	soil specific
q_{acrack}	air porosity of soil in foundation cracks	soil specific
q_{wcrack}	water porosity of soil in foundation cracks	soil specific
W	width of source area parallel to wind direction (cm)	1500
U_{air}	wind speed above ground surface (cm/s)	225
d_{air}	ambient air mixing zone height (cm)	150
D_s^{eff}, D_E	diffusion coefficient in soil (cm^2/s)	chem/soil specific
H, K_H	Henry's constant (cm^3H_2O/cm^3air)	chemical specific
k_s, K_D	soil-water sorption coefficient (foc x K_{oc})	chem/soil specific
Foc	fraction organic carbon	soil specific
Koc	organic carbon adsorption coefficient	chemical specific
D^{wat}	diffusion coefficient in water (cm^2/s)	chemical specific
D^{air}	diffusion coefficient in air (cm^2/s)	chemical specific
d, ΔH	layer thickness of contaminated soil (cm)	200
h_v	thickness of vadose zone (cm) - (L_{GW} - h_{cap})	depth & soil spec.
h_{cap}	thickness of capillary fringe (cm)	soil specific
ER	enclosed space air exchange rate (s^{-1}) residential	0.00056
	commercial/industrial	0.00056
L_B	enclosed space volume/infiltration area ratio (cm) residential	200
	commercial/industrial	300
L_{crack}	enclosed space foundation or wall thickness (cm)	20
h	areal fraction of cracks in foundation/walls ($cm^2_{cracks}/cm^2_{total\ A}$)	0.01
L_{GW}	depth to ground water (cm)	200 / 400 / 800
t	averaging time period (s) Non-carcinogenic (7 yr)	220,752,000
	Carcinogenic - commercial (20 yr)	630,720,000
	Carcinogenic - residential (30 yr)	946,080,000
L_S, L_T^o	initial separation of building slab & soil (cm)	0 / 100 / 400
Z	distance from top of contamination layer	0 (top)
V_E	effective solute advective velocity (cm/s)	0
m	degradation rate (1/s)	0
H_E	boundary condition term	site,soil,chem spec.
μ_v	Vapour viscosity (g/cm.s)	1.8×10^{-4}
ΔP	Pressure difference of indoor air and soil ($g/cm.s^2$)	35
Co	initial concentration (mg/cm^3) - arbitrary number	1

Table 4Db Soil properties for volatilisation modelling

Soil Type	Example	Air Filled Porosity (unitless)	Water Filled Porosity (unitless)	Total Porosity (unitless)	Organic Carbon Content (%)	Bulk Density (tonne/m^3)	AirPermeability (cm^2)	Capillary Fringe Thickness (m)
Sand, sandy loam, silty sand	Recent (R), yellow brown sands (YBS)	0.26	0.12	0.38	0.3	1.9	1×10^{-8}	0.05
Silts, sandy silts, silty loams, clayey sand	Yellow grey earths (YG), yellow brown earth (YB)	0.18	0.27	0.45	0.3	1.9	1×10^{-9}	0.3
Silty clay, clay loam, sandy clay		0.06	0.44	0.5	0.3	1.8	7×10^{-10}	0.8
Clay		0.02	0.48	0.5	0.3	1.8	6×10^{-11}	1
Pumice	Pumice sands (YBP)	0.2	0.35	0.55	0.5	1.7	4×10^{-8}	0.5
Peats and other highly organic soils		0.23	0.23	0.46	12	1.6	1×10^{-9}	0.3
Fractured basalts		0.08	0.03	0.11	<0.1	2.4	1×10^{-9}	0.05
Gravel		0.25	0.03	0.28	<0.1	2	1×10^{-5}	0.05

1.9 Discussion of results

The results of the volatilisation modelling of diffusive transport from soil to indoor and outdoor air (Jury model) are presented in Tables 4D1 a-f and 4D2 a-f. The results of modelling advective transport are presented in Tables 4D3 a-f and 4D4 a-f.

A review of the results from the Jury model indicates slightly higher criteria are nominated for the sand soil type compared to the silty sand soil type for the indoor air pathway. The reason for this apparent discrepancy is as follows:

- the Jury model allows for diffusion both upward and downward
- for all soil types except sand the resistance to downward migration (assuming a uniform soil type of infinite depth) is greater than that for upward migration (i.e. through a layer of soil and a concrete building foundation). On this basis the mass of contaminant migrating downward is relatively minor.
- sand has a low resistance to migration through the soil. Large resistance from the concrete foundation produces a greater resistance upwards than that downwards. Therefore, a significant quantity of contaminant migrates downward, rather than upward and into the building (hence criteria for this soil type are higher).

In practice groundwater or other features would limit the downward diffusion of contaminants (i.e. the assumption of a uniform soil of infinite depth does not hold) and therefore where the calculated criteria for sand are higher than those for silty sand, the values for silty sand have been adopted for sand in Tables 4.10 to 4.15 of Module 4.

All of the acceptance criteria derived for soils are based on an initial thickness of the contaminated layer of 2 metres. This is expected to be a reasonable value reflecting a conservative estimate of that typically remaining at many sites. Where a thicker contaminated zone remains on-site in most cases it is only likely to be two to three times the thickness selected and therefore at worst the nominated criteria could be in error by a similar factor.

1.10 References

Ferguson C.C., Krylon V.V., and McGrath P.T. 1995. **Contamination of indoor air by toxic soil vapours: a screening risk assessment model,** Building and Environment, 30, 375-385.

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Jury W.A., Spencer W.F., and Farme W.J. 1983**. Behaviour Assessment Model for Trace Organics in Soil: 1. Model Description.** J. Environ. Qual. Vol,12, No.4.

Millington J.J and Quirk J.P. 1961. **Permeability of Porous Solid.** Trans. Faraday Soc., 57. 1200-1207

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Table 4D1a Preliminary Health Risk Based Acceptance Criteria - Soil - *Residential and Agricultural Site Use* SAND SOIL Type

Site Use:	Residential	Exposure Frequency:	350 d/yr	Inhalation rate indoor:	15 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	20 m^3/d
		(non carc):	30 yr		
Target Risk:	0.00001	Exposure Dur:	30 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)					
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors			Outdoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface	>1 m	>4 m	Surface	>1 m	>4 m
Alkanes										
C_7 - C_9		5		5	6.20E-03	6.01E-03	5.51E-03	7.65E-05	6.94E-05	5.92E-05
C_{10} - C_{14}		0.3		0.3	5.21E-04	4.98E-04	4.38E-04	5.47E-05	2.62E-05	1.08E-05
C_{15} - C_{36}		1.5		1.5	8.62E-07	9.85E-07	8.62E-07	2.24E-06	9.85E-08	2.53E-08
MAHs										
benzene	0.029		3.45E-04		1.71E-03	1.66E-03	1.53E-03	1.79E-05	1.66E-05	1.47E-05
toluene		0.11		0.11	2.67E-03	2.56E-03	2.29E-03	7.65E-05	5.78E-05	3.88E-05
ethylbenzene		0.029		0.029	1.41E-03	1.35E-03	1.20E-03	7.65E-05	4.58E-05	2.49E-05
xylene		0.09		0.09	2.87E-03	2.76E-03	2.47E-03	7.65E-05	5.90E-05	4.06E-05
Aromatics										
naphthalene		0.004		0.004	2.92E-04	2.78E-04	2.44E-04	3.89E-05	1.72E-05	6.34E-06
pyrene		0.03		0.03	3.40E-08	3.24E-08	2.84E-08	4.06E-07	3.34E-09	8.39E-10
Benzo(a)pyrene	7.3		1.37E-06		4.31E-10	4.11E-10	3.60E-10	2.21E-08	1.31E-11	3.28E-12

	Risk Based Screening Level (mg/kg)											
Contaminant	Carcinogenic						Non-carcinogenic					
	Outdoors			Indoors			Outdoors			Indoors		
Alkanes	Surface	>1 m	>4 m	Surface	>1 m	>4 m	Surface	>1 m	>4 m	Surface	>1 m	>4 m
C_7 - C_9							2.39E+05	2.63E+05	3.08E+05	3.92E+03	4.05E+03	4.42E+03
C_{10} - C_{14}							2.00E+04	4.18E+04	1.02E+05	2.80E+03	2.93E+03	3.33E+03
C_{15} - C_{36}							2.45E+06	5.56E+07	2.16E+08	8.47E+06	7.41E+06	8.47E+06
MAHs												
benzene	1.65E+02	1.77E+02	2.00E+02	2.29E+00	2.36E+00	2.55E+00						
toluene							5.25E+03	6.94E+03	1.03E+04	2.00E+02	2.09E+02	2.34E+02
ethylbenzene							1.38E+03	2.31E+03	4.26E+03	1.00E+02	1.04E+02	1.18E+02
xylene							4.29E+03	5.56E+03	8.10E+03	1.52E+02	1.59E+02	1.78E+02
Aromatics												
naphthalene							3.75E+02	8.47E+02	2.30E+03	6.67E+01	7.00E+01	7.97E+01
pyrene							2.70E+05	3.28E+07	1.31E+08	4.29E+06	4.51E+06	5.15E+06
benzo (a) pyrene	5.29E+02	8.90E+05	3.56E+06	3.61E+04	3.79E+04	4.33E+04						

Table 4D1b Preliminary Health Risk Based Acceptance Criteria - Soil *Residential and Agricultural Site Use* SILT SOIL Type

Site Use:	Residential	Exposure Frequency:	350 d/yr	Inhalation rate indoor:	15 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	20 m^3/d
		(non carc):	30 yr		
Target Risk:	0.00001	Exposure Dur:	30 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)					
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors			Outdoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface	>1m	>4m	Surface	>1m	>4m
Alkanes										
C_7 - C_9		5		5	8.92E-03	8.13E-03	6.39E-03	7.65E-05	6.18E-05	4.49E-05
C_{10} - C_{14}		0.3		0.3	5.59E-04	4.60E-04	3.00E-04	2.51E-05	8.78E-06	2.88E-06
C_{15} - C_{36}		1.5		1.5	5.29E-07	8.33E-07	5.29E-07	1.02E-06	2.10E-08	5.33E-09
MAHs										
benzene	0.029		3.45E-04		2.19E-03	2.01E-03	1.60E-03	1.79E-05	1.47E-05	1.10E-05
toluene		0.11		0.11	3.74E-03	3.20E-03	2.23E-03	7.65E-05	3.90E-05	1.91E-05
ethylbenzene		0.029		0.029	1.84E-03	1.54E-03	1.03E-03	4.99E-05	2.36E-05	9.41E-06
xylene		0.09		0.09	4.03E-03	3.46E-03	2.42E-03	7.65E-05	4.08E-05	2.05E-05
Aromatics										
naphthalene		0.004		0.004	2.86E-04	2.35E-04	1.52E-04	1.77E-05	4.87E-06	1.49E-06
pyrene		0.03		0.03	3.40E-08	3.18E-08	2.67E-08	3.46E-07	2.42E-09	6.09E-10
benzo (a) pyrene	7.3		1.37E-06		4.31E-10	4.25E-10	4.07E-10	4.07E-08	1.38E-10	3.47E-11

	Risk Based Screening Level (mg/kg)											
Contaminant	Carcinogenic						Non-carcinogenic					
	Outdoors			Indoors			Outdoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9							2.39E+05	2.95E+05	4.07E+05	2.73E+03	2.99E+03	3.81E+03
C_{10} - C_{14}							4.37E+04	1.25E+05	3.81E+05	2.61E+03	3.18E+03	4.87E+03
C_{15} - C_{36}							5.34E+06	2.60E+08	1.03E+09	1.38E+07	8.76E+06	1.38E+07
MAHs												
benzene	1.65E+02	1.99E+02	2.66E+02	1.79E+00	1.95E+00	2.44E+00						
toluene							5.25E+03	1.03E+04	2.10E+04	1.43E+02	1.67E+02	2.40E+02
ethylbenzene							2.12E+03	4.48E+03	1.12E+04	7.68E+01	9.19E+01	1.37E+02
xylene							4.29E+03	8.05E+03	1.60E+04	1.09E+02	1.27E+02	1.81E+02
Aromatics												
naphthalene							8.23E+02	3.00E+03	9.80E+03	6.79E+01	8.29E+01	1.28E+02
pyrene							3.17E+05	4.52E+07	1.80E+08	4.29E+06	4.59E+06	5.48E+06
benzo (a) pyrene	2.87E+02	8.43E+04	3.37E+05	3.61E+04	3.66E+04	3.82E+04						

Table 4D1c Preliminary Health Risk Based Acceptance Criteria - Soil *Residential and Agricultural Site Use* SILTY CLAY Soil Type

Site Use:	Residential	Exposure Frequency:	350 d/yr	Inhalation rate indoor:	15 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	20 m^3/d
		(non carc):	30 yr		
Target Risk:	0.00001	Exposure Dur:	30 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)					
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors			Outdoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface	>1m	>4m	Surface	>1m	>4m
Alkanes										
C_7 - C_9		5		5	6.65E-03	3.32E-03	1.27E-03	3.84E-05	1.72E-05	6.40E-06
C_{10} - C_{14}		0.3		0.3	3.48E-04	4.70E-05	1.30E-05	3.53E-06	2.51E-07	6.57E-08
C_{15} - C_{36}		1.5		1.5	2.21E-08	8.28E-08	2.21E-08	1.44E-07	4.45E-10	1.11E-10
MAHs										
benzene	0.029		3.45E-04		1.61E-03	8.48E-04	3.36E-04	9.70E-06	4.46E-06	1.70E-06
toluene		0.11		0.11	2.00E-03	5.64E-04	1.76E-04	1.33E-05	3.04E-06	8.95E-07
ethylbenzene		0.029		0.029	9.34E-04	1.76E-04	5.09E-05	7.80E-06	9.37E-07	2.57E-07
xylene		0.09		0.09	2.14E-03	6.22E-04	1.96E-04	1.40E-05	3.35E-06	9.93E-07
Aromatics										
naphthalene		0.004		0.004	2.30E-04	5.91E-05	1.83E-05	4.27E-06	3.64E-07	9.62E-08
pyrene		0.03		0.03	3.40E-08	3.32E-08	3.11E-08	5.82E-07	7.23E-09	1.82E-09
benzo (a) pyrene	7.3		1.37E-06		4.31E-10	4.30E-10	4.25E-10	7.86E-08	5.69E-10	1.43E-10

	Risk Based Screening Level (mg/kg)											
Contaminant	Carcinogenic						Non-carcinogenic					
	Outdoors			Indoors			Outdoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9							4.75E+05	1.06E+06	2.85E+06	3.66E+03	7.33E+03	1.91E+04
C_{10} - C_{14}							3.10E+05	4.36E+06	1.67E+07	4.20E+03	3.11E+04	1.12E+05
C_{15} - C_{36}							3.80E+07	1.23E+10	4.92E+10	3.31E+08	8.81E+07	3.31E+08
MAHs												
benzene	3.03E+02	6.59E+02	1.73E+03	2.43E+00	4.62E+00	1.17E+01						
toluene							3.02E+04	1.32E+05	4.49E+05	2.68E+02	9.49E+02	3.03E+03
ethylbenzene							1.36E+04	1.13E+05	4.13E+05	1.51E+02	8.02E+02	2.77E+03
xylene							2.34E+04	9.82E+04	3.31E+05	2.05E+02	7.05E+02	2.24E+03
Aromatics												
naphthalene							3.42E+03	4.01E+04	1.52E+05	8.46E+01	3.29E+02	1.06E+03
pyrene							1.88E+05	1.51E+07	6.01E+07	4.30E+06	4.40E+06	4.69E+06
benzo (a) pyrene	1.48E+02	2.05E+04	8.16E+04	3.61E+04	3.62E+04	3.66E+04						

Table 4D1d Preliminary Health Risk Based Acceptance Criteria - Soil *Residential and Agricultural Site Use* CLAY Soil Type

Site Use:	Residential	Exposure Frequency:	350 d/yr	Inhalation rate indoor:	15 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	20 m^3/d
		(non carc):	30 yr		
Target Risk:	0.00001	Exposure Dur:	30 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)					
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors			Outdoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface	>1m	>4m	Surface	>1m	>4m
Alkanes										
C_7 - C_9		5		5	1.31E-03	1.65E-04	4.49E-05	6.54E-06	8.15E-07	2.22E-07
C_{10} - C_{14}		0.3		0.3	1.00E-04	1.41E-06	3.56E-07	5.75E-07	6.99E-09	1.76E-09
C_{15} - C_{36}		1.5		1.5	5.98E-10	2.39E-09	5.98E-10	2.35E-08	1.18E-11	2.96E-12
MAHs										
benzene	0.029		3.45E-04		1.14E-03	4.44E-04	1.52E-04	6.08E-06	2.27E-06	7.58E-07
toluene		0.11		0.11	1.31E-03	2.23E-04	6.31E-05	7.77E-06	1.14E-06	3.15E-07
ethylbenzene		0.029		0.029	3.09E-04	1.23E-05	3.17E-06	4.27E-06	6.12E-08	1.57E-08
xylene		0.09		0.09	1.38E-03	2.39E-04	6.79E-05	8.06E-06	1.22E-06	3.38E-07
Aromatics										
naphthalene		0.004		0.004	2.26E-04	5.45E-05	1.66E-05	4.05E-06	3.29E-07	8.68E-08
pyrene		0.03		0.03	3.40E-08	3.34E-08	3.18E-08	6.72E-07	9.63E-09	2.43E-09
benzo (a) pyrene	7.3		1.37E-06		4.31E-10	4.30E-10	4.27E-10	9.09E-08	7.60E-10	1.91E-10

	Risk Based Screening Level (mg/kg)											
Contaminant	Carcinogenic						Non-carcinogenic					
	Outdoors			Indoors			Outdoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9							2.79E+06	2.24E+07	8.22E+07	1.86E+04	1.48E+05	5.42E+05
C_{10} - C_{14}							1.91E+06	1.57E+08	6.22E+08	1.46E+04	1.03E+06	4.10E+06
C_{15} - C_{36}							2.33E+08	4.63E+11	1.85E+12	1.22E+10	3.06E+09	1.22E+10
MAHs												
benzene	4.83E+02	1.30E+03	3.87E+03	3.45E+00	8.82E+00	2.58E+01						
toluene							5.17E+04	3.53E+05	1.28E+06	4.09E+02	2.40E+03	8.48E+03
ethylbenzene							2.48E+04	1.73E+06	6.76E+06	4.56E+02	1.14E+04	4.45E+04
xylene							4.08E+04	2.69E+05	9.71E+05	3.18E+02	1.83E+03	6.45E+03
Aromatics												
naphthalene							3.61E+03	4.44E+04	1.68E+05	8.60E+01	3.57E+02	1.17E+03
pyrene							1.63E+05	1.14E+07	4.51E+07	4.30E+06	4.37E+06	4.59E+06
benzo (a) pyrene	1.28E+02	1.53E+04	6.11E+04	3.61E+04	3.62E+04	3.65E+04						

Table 4D1e Preliminary Health Risk Based Acceptance Criteria - Soil *Residential and Agricultural Site Use* PUMICE Soil Type

Site Use:	Residential	Exposure Frequency:	350 d/yr	Inhalation rate indoor:	15 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	20 m^3/d
		(non carc):	30 yr		
Target Risk:	0.00001	Exposure Dur:	30 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)					
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors			Outdoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface	>1m	>4m	Surface	>1m	>4m
Alkanes										
C_7 - C_9		5		5	7.32E-03	6.58E-03	5.02E-03	6.85E-05	5.27E-05	3.61E-05
C_{10} - C_{14}		0.3		0.3	3.42E-04	2.78E-04	1.78E-04	1.79E-05	5.38E-06	1.68E-06
C_{15} - C_{36}		1.5		1.5	3.09E-07	4.95E-07	3.09E-07	7.32E-07	1.20E-08	3.04E-09
MAHs										
benzene	0.029		3.45E-04		1.81E-03	1.63E-03	1.26E-03	1.60E-05	1.26E-05	8.91E-06
toluene		0.11		0.11	2.69E-03	2.26E-03	1.54E-03	6.18E-05	2.94E-05	1.33E-05
ethylbenzene		0.029		0.029	1.21E-03	9.94E-04	6.52E-04	3.58E-05	1.60E-05	5.93E-06
xylene		0.09		0.09	2.93E-03	2.47E-03	1.69E-03	6.62E-05	3.12E-05	1.44E-05
Aromatics										
naphthalene		0.004		0.004	1.75E-04	1.42E-04	9.05E-05	1.27E-05	2.96E-06	8.73E-07
pyrene		0.03		0.03	2.04E-08	1.95E-08	1.71E-08	3.01E-07	2.06E-09	5.17E-10
benzo (a) pyrene	7.3		1.37E-06		2.59E-10	2.56E-10	2.49E-10	3.72E-08	1.32E-10	3.31E-11

	Risk Based Screening Level (mg/kg)											
Contaminant	Carcinogenic						Non-carcinogenic					
	Outdoors			Indoors			Outdoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9							2.67E+05	3.46E+05	5.06E+05	3.32E+03	3.70E+03	4.85E+03
C_{10} - C_{14}							6.11E+04	2.04E+05	6.51E+05	4.27E+03	5.26E+03	8.21E+03
C_{15} - C_{36}							7.48E+06	4.54E+08	1.80E+09	2.36E+07	1.47E+07	2.36E+07
MAHs												
benzene	1.84E+02	2.33E+02	3.29E+02	2.17E+00	2.40E+00	3.10E+00						
toluene							6.49E+03	1.36E+04	3.03E+04	1.99E+02	2.36E+02	3.49E+02
ethylbenzene							2.95E+03	6.62E+03	1.79E+04	1.17E+02	1.42E+02	2.17E+02
xylene							4.96E+03	1.05E+04	2.28E+04	1.50E+02	1.77E+02	2.60E+02
Aromatics												
naphthalene							1.15E+03	4.94E+03	1.67E+04	1.11E+02	1.37E+02	2.15E+02
pyrene							3.64E+05	5.32E+07	2.12E+08	7.16E+06	7.50E+06	8.55E+06
benzo (a) pyrene	3.13E+02	8.84E+04	3.53E+05	6.01E+04	6.07E+04	6.23E+04						

Table 4D1f Preliminary Health Risk Based Acceptance Criteria - Soil *Residential and Agricultural Site Use* PEATS and HIGH ORGANIC Soil Type

Site Use:	Residential	Exposure Frequency:	350 d/yr	Inhalation rate indoor:	15 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	20 m^3/d
		(non carc):	30 yr		
Target Risk:	0.00001	Exposure Dur:	30 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)					
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors			Outdoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface	>1m	>4m	Surface	>1m	>4m
Alkanes										
C_7 - C_9		5		5	1.41E-03	1.29E-03	1.02E-03	6.18E-05	2.92E-05	1.35E-05
C_{10} - C_{14}		0.3		0.3	1.54E-05	1.39E-05	1.07E-05	5.36E-06	6.26E-07	1.69E-07
C_{15} - C_{36}		1.5		1.5	1.80E-08	2.33E-08	1.80E-08	2.19E-07	1.15E-09	2.90E-10
MAHs										
benzene	0.029		3.45E-04		4.22E-04	3.87E-04	3.08E-04	1.50E-05	7.87E-06	3.92E-06
toluene		0.11		0.11	2.03E-04	1.83E-04	1.43E-04	1.98E-05	6.66E-06	2.15E-06
ethylbenzene		0.029		0.029	6.30E-05	5.69E-05	4.40E-05	1.09E-05	2.35E-06	6.84E-07
xylene		0.09		0.09	2.39E-04	2.16E-04	1.68E-04	2.16E-05	7.68E-06	2.53E-06
Aromatics										
naphthalene		0.004		0.004	7.90E-06	7.13E-06	5.50E-06	3.84E-06	3.31E-07	8.78E-08
pyrene		0.03		0.03	8.51E-10	7.96E-10	6.68E-10	5.02E-08	6.10E-11	1.53E-11
benzo (a) pyrene	7.3		1.37E-06		1.08E-11	1.05E-11	9.87E-12	4.68E-09	1.95E-12	4.87E-13

	Risk Based Screening Level (mg/kg)											
Contaminant	Carcinogenic						Non-carcinogenic					
	Outdoors			Indoors			Outdoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9							2.95E+05	6.25E+05	1.36E+06	1.73E+04	1.89E+04	2.39E+04
C_{10} - C_{14}							2.04E+05	1.75E+06	6.46E+06	9.50E+04	1.05E+05	1.36E+05
C_{15} - C_{36}							2.50E+07	4.74E+09	1.89E+10	4.06E+08	3.13E+08	4.06E+08
MAHs												
benzene	1.95E+02	3.73E+02	7.49E+02	9.27E+00	1.01E+01	1.27E+01						
toluene							2.03E+04	6.03E+04	1.87E+05	2.64E+03	2.92E+03	3.76E+03
ethylbenzene							9.69E+03	4.51E+04	1.55E+05	2.24E+03	2.48E+03	3.21E+03
xylene							1.52E+04	4.28E+04	1.30E+05	1.83E+03	2.02E+03	2.60E+03
Aromatics												
naphthalene							3.80E+03	4.40E+04	1.66E+05	2.46E+03	2.73E+03	3.54E+03
pyrene							2.18E+06	1.79E+09	7.17E+09	1.72E+08	1.83E+08	2.19E+08
benzo (a) pyrene	2.49E+03	6.00E+06	2.40E+07	1.44E+06	1.48E+06	1.58E+06						

Table 4D2a Preliminary Health Risk Based Acceptance Criteria - Soil *Commercial/Industrial Site Use* SAND Soil Type

Site Use:	Residential	Exposure Frequency:	240 d/yr	Inhalation rate indoor:	10 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	10 m^3/d
		(non carc):	20 yr		
Target Risk:	0.00001	Exposure Dur:	20 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)					
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors			Outdoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface	>1m	>4m	Surface	>1m	>4m
Alkanes										
C_7 - C_9		5		5	4.13E-03	4.01E-03	3.67E-03	7.65E-05	6.94E-05	5.92E-05
C_{10} - C_{14}		0.3		0.3	3.48E-04	3.32E-04	2.92E-04	5.47E-05	2.62E-05	1.08E-05
C_{15} - C_{36}		1.5		1.5	5.75E-07	6.56E-07	5.75E-07	2.24E-06	9.85E-08	2.53E-08
MAHs										
benzene	0.029		3.45E-04		1.50E-03	1.45E-03	1.33E-03	2.68E-05	2.44E-05	2.10E-05
toluene		0.11		0.11	1.78E-03	1.71E-03	1.53E-03	7.65E-05	5.78E-05	3.88E-05
ethylbenzene		0.029		0.029	9.41E-04	9.01E-04	7.97E-04	7.65E-05	4.58E-05	2.49E-05
xylene		0.09		0.09	1.91E-03	1.84E-03	1.64E-03	7.65E-05	5.90E-05	4.06E-05
Aromatics										
naphthalene		0.004		0.004	1.94E-04	1.85E-04	1.63E-04	3.89E-05	1.72E-05	6.34E-06
pyrene		0.03		0.03	2.27E-08	2.16E-08	1.89E-08	4.06E-07	3.34E-09	8.39E-10
benzo (a) pyrene	7.3		1.37E-06		8.86E-11	8.44E-11	7.38E-11	2.70E-08	1.31E-11	3.28E-12

	Risk Based Screening Level (mg/kg)											
Contaminant	Carcinogenic						Non-carcinogenic					
	Outdoors			Indoors			Outdoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9							6.96E+05	7.67E+05	8.99E+05	1.29E+04	1.33E+04	1.45E+04
C_{10} - C_{14}							5.84E+04	1.22E+05	2.96E+05	9.19E+03	9.63E+03	1.09E+04
C_{15} - C_{36}							7.14E+06	1.62E+08	6.30E+08	2.78E+07	2.43E+07	2.78E+07
MAHs												
benzene	4.80E+02	5.26E+02	6.12E+02	8.58E+00	8.85E+00	9.65E+00						
toluene							1.53E+04	2.03E+04	3.02E+04	6.58E+02	6.85E+02	7.68E+02
ethylbenzene							4.04E+03	6.74E+03	1.24E+04	3.28E+02	3.43E+02	3.87E+02
xylene							1.25E+04	1.62E+04	2.36E+04	5.00E+02	5.21E+02	5.83E+02
Aromatics												
naphthalene							1.09E+03	2.47E+03	6.72E+03	2.19E+02	2.30E+02	2.61E+02
pyrene							7.87E+05	9.57E+07	3.81E+08	1.41E+07	1.48E+07	1.69E+07
benzo (a) pyrene	1.89E+03	3.89E+06	1.56E+07	5.76E+05	6.05E+05	6.92E+05						

Table 4D2b Preliminary Health Risk Based Acceptance Criteria - Soil *Commercial/Industrial Site Use* SILT Soil Type

Site Use:	Residential	Exposure Frequency:	240 d/yr	Inhalation rate indoor:	10 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	10 m^3/d
		(non carc):	20 yr		
Target Risk:	0.00001	Exposure Dur:	20 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)					
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors			Outdoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface	>1m	>4m	Surface	>1m	>4m
Alkanes										
C_7 - C_9		5		5	5.95E-03	5.42E-03	4.26E-03	7.65E-05	6.18E-05	4.49E-05
C_{10} - C_{14}		0.3		0.3	3.73E-04	3.06E-04	2.00E-04	2.51E-05	8.78E-06	2.88E-06
C_{15} - C_{36}		1.5		1.5	3.52E-07	5.55E-07	3.52E-07	1.02E-06	2.10E-08	5.33E-09
MAHs										
benzene	0.029		3.45E-04		1.97E-03	1.78E-03	1.38E-03	2.68E-05	2.11E-05	1.49E-05
toluene		0.11		0.11	2.50E-03	2.14E-03	1.49E-03	7.65E-05	3.90E-05	1.91E-05
ethylbenzene		0.029		0.029	1.22E-03	1.02E-03	6.87E-04	4.99E-05	2.36E-05	9.41E-06
xylene		0.09		0.09	2.68E-03	2.30E-03	1.61E-03	7.65E-05	4.08E-05	2.05E-05
Aromatics										
naphthalene		0.004		0.004	1.91E-04	1.57E-04	1.02E-04	1.77E-05	4.87E-06	1.49E-06
pyrene		0.03		0.03	2.27E-08	2.12E-08	1.78E-08	3.46E-07	2.42E-09	6.09E-10
benzo (a) pyrene	7.3		1.37E-06		8.86E-11	8.81E-11	8.69E-11	4.98E-08	1.38E-10	3.47E-11

	Risk Based Screening Level (mg/kg)											
Contaminant	Carcinogenic						Non-carcinogenic					
	Outdoors			Indoors			Outdoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9							6.96E+05	8.62E+05	1.19E+06	8.95E+03	9.82E+03	1.25E+04
C_{10} - C_{14}							1.27E+05	3.64E+05	1.11E+06	8.57E+03	1.04E+04	1.60E+04
C_{15} - C_{36}							1.56E+07	7.59E+08	3.00E+09	4.53E+07	2.87E+07	4.53E+07
MAHs												
benzene	4.80E+02	6.09E+02	8.64E+02	6.53E+00	7.21E+00	9.29E+00						
toluene							1.53E+04	3.00E+04	6.13E+04	4.69E+02	5.48E+02	7.87E+02
ethylbenzene							6.18E+03	1.31E+04	3.28E+04	2.52E+02	3.01E+02	4.49E+02
xylene							1.25E+04	2.35E+04	4.66E+04	3.57E+02	4.16E+02	5.94E+02
Aromatics												
naphthalene							2.40E+03	8.74E+03	2.86E+04	2.23E+02	2.72E+02	4.19E+02
pyrene							9.24E+05	1.32E+08	5.25E+08	1.41E+07	1.51E+07	1.80E+07
benzo (a) pyrene	1.02E+03	3.69E+05	1.47E+06	5.76E+05	5.79E+05	5.87E+05						

Table 4D2c Preliminary Health Risk Based Acceptance Criteria - Soil *Commercial/Industrial Site Use* SILTY CLAY Soil Type

Site Use:	Residential	Exposure Frequency:	240 d/yr	Inhalation rate indoor:	10 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	10 m^3/d
		(non carc):	20 yr		
Target Risk:	0.00001	Exposure Dur:	20 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)					
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors			Outdoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface	>1m	>4m	Surface	>1m	>4m
Alkanes										
C_7 - C_9		5		5	4.44E-03	2.21E-03	8.48E-04	3.84E-05	1.72E-05	6.40E-06
C_{10} - C_{14}		0.3		0.3	2.32E-04	3.13E-05	8.69E-06	3.53E-06	2.51E-07	6.57E-08
C_{15} - C_{36}		1.5		1.5	1.47E-08	5.52E-08	1.47E-08	1.44E-07	4.45E-10	1.11E-10
MAHs										
benzene	0.029		3.45E-04		1.35E-03	6.39E-04	2.39E-04	1.19E-05	5.08E-06	1.82E-06
toluene		0.11		0.11	1.33E-03	3.76E-04	1.18E-04	1.33E-05	3.04E-06	8.95E-07
ethylbenzene		0.029		0.029	6.22E-04	1.17E-04	3.39E-05	7.80E-06	9.37E-07	2.57E-07
xylene		0.09		0.09	1.43E-03	4.14E-04	1.31E-04	1.40E-05	3.35E-06	9.93E-07
Aromatics										
naphthalene		0.004		0.004	1.53E-04	3.94E-05	1.22E-05	4.27E-06	3.64E-07	9.62E-08
pyrene		0.03		0.03	2.26E-08	2.21E-08	2.07E-08	5.82E-07	7.23E-09	1.82E-09
benzo (a) pyrene	7.3		1.37E-06		8.86E-11	8.85E-11	8.82E-11	9.63E-08	5.69E-10	1.43E-10

	Risk Based Screening Level (mg/kg)											
Contaminant	Carcinogenic						Non-carcinogenic					
	Outdoors			Indoors			Outdoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9							1.39E+06	3.10E+06	8.32E+06	1.20E+04	2.40E+04	6.28E+04
C_{10} - C_{14}							9.05E+05	1.27E+07	4.86E+07	1.38E+04	1.02E+05	3.68E+05
C_{15} - C_{36}							1.11E+08	3.59E+10	1.43E+11	1.09E+09	2.89E+08	1.09E+09
MAHs												
benzene	1.08E+03	2.53E+03	7.06E+03	9.53E+00	2.01E+01	5.37E+01						
toluene							8.81E+04	3.85E+05	1.31E+06	8.80E+02	3.11E+03	9.95E+03
ethylbenzene							3.96E+04	3.29E+05	1.20E+06	4.96E+02	2.63E+03	9.11E+03
xylene							6.83E+04	2.86E+05	9.65E+05	6.71E+02	2.31E+03	7.34E+03
Aromatics												
naphthalene							9.98E+03	1.17E+05	4.43E+05	2.78E+02	1.08E+03	3.49E+03
pyrene							5.49E+05	4.42E+07	1.75E+08	1.41E+07	1.44E+07	1.54E+07
benzo (a) pyrene	5.30E+02	8.96E+04	3.57E+05	5.76E+05	5.77E+05	5.79E+05						

Table 4D2d Preliminary Health Risk Based Acceptance Criteria - Soil *Commercial/Industrial Site Use* CLAY Soil Type

Site Use:	Residential	Exposure Frequency:	240 d/yr	Inhalation rate indoor:	10 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	10 m^3/d
		(non carc):	20 yr		
Target Risk:	0.00001	Exposure Dur:	20 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)					
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors			Outdoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface	>1m	>4m	Surface	>1m	>4m
Alkanes										
C_7 - C_9		5		5	8.72E-04	1.10E-04	2.99E-05	6.54E-06	8.15E-07	2.22E-07
C_{10} - C_{14}		0.3		0.3	6.68E-05	9.41E-07	2.38E-07	5.75E-07	6.99E-09	1.76E-09
C_{15} - C_{36}		1.5		1.5	3.99E-10	1.59E-09	3.99E-10	2.35E-08	1.18E-11	2.96E-12
MAHs										
benzene	0.029		3.45E-04		9.20E-04	3.17E-04	1.04E-04	7.45E-06	2.43E-06	7.77E-07
toluene		0.11		0.11	8.74E-04	1.49E-04	4.21E-05	7.77E-06	1.14E-06	3.15E-07
ethylbenzene		0.029		0.029	2.06E-04	8.22E-06	2.11E-06	4.27E-06	6.12E-08	1.57E-08
xylene		0.09		0.09	9.18E-04	1.59E-04	4.52E-05	8.06E-06	1.22E-06	3.38E-07
Aromatics										
naphthalene		0.004		0.004	1.51E-04	3.63E-05	1.11E-05	4.05E-06	3.29E-07	8.68E-08
pyrene		0.03		0.03	2.26E-08	2.23E-08	2.12E-08	6.72E-07	9.63E-09	2.43E-09
benzo (a) pyrene	7.3		1.37E-06		8.86E-11	8.85E-11	8.83E-11	1.11E-07	7.60E-10	1.91E-10

	Risk Based Screening Level (mg/kg)											
Contaminant	Carcinogenic						Non-carcinogenic					
	Outdoors			Indoors			Outdoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9							8.14E+06	6.53E+07	2.40E+08	6.11E+04	4.85E+05	1.78E+06
C_{10} - C_{14}							5.56E+06	4.57E+08	1.81E+09	4.78E+04	3.39E+06	1.34E+07
C_{15} - C_{36}							6.79E+08	1.35E+12	5.40E+12	4.00E+10	1.00E+10	4.00E+10
MAHs												
benzene	1.73E+03	5.29E+03	1.65E+04	1.40E+01	4.05E+01	1.24E+02						
toluene							1.51E+05	1.03E+06	3.72E+06	1.34E+03	7.89E+03	2.78E+04
ethylbenzene							7.23E+04	5.04E+06	1.97E+07	1.50E+03	3.75E+04	1.46E+05
xylene							1.19E+05	7.85E+05	2.83E+06	1.04E+03	6.01E+03	2.12E+04
Aromatics												
naphthalene							1.05E+04	1.29E+05	4.91E+05	2.82E+02	1.17E+03	3.85E+03
pyrene							4.75E+05	3.32E+07	1.31E+08	1.41E+07	1.43E+07	1.51E+07
benzo (a) pyrene	4.59E+02	6.71E+04	2.67E+05	5.76E+05	5.77E+05	5.78E+05						

Table 4D2e Preliminary Health Risk Based Acceptance Criteria - Soil *Commercial/Industrial Site Use* PUMICE Soil Type

Site Use:	Residential	Exposure Frequency:	240 d/yr	Inhalation rate indoor:	10 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	10 m^3/d
		(non carc):	20 yr		
Target Risk:	0.00001	Exposure Dur:	20 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)					
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors			Outdoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface	>1m	>4m	Surface	>1m	>4m
Alkanes										
C_7 - C_9		5		5	4.88E-03	4.39E-03	3.35E-03	6.85E-05	5.27E-05	3.61E-05
C_{10} - C_{14}		0.3		0.3	2.28E-04	1.85E-04	1.19E-04	1.79E-05	5.38E-06	1.68E-06
C_{15} - C_{36}		1.5		1.5	2.06E-07	3.30E-07	2.06E-07	7.32E-07	1.20E-08	3.04E-09
MAHs										
benzene	0.029		3.45E-04		1.60E-03	1.42E-03	1.07E-03	2.40E-05	1.79E-05	1.18E-05
toluene		0.11		0.11	1.79E-03	1.51E-03	1.02E-03	6.18E-05	2.94E-05	1.33E-05
ethylbenzene		0.029		0.029	8.03E-04	6.63E-04	4.34E-04	3.58E-05	1.60E-05	5.93E-06
xylene		0.09		0.09	1.95E-03	1.65E-03	1.12E-03	6.62E-05	3.12E-05	1.44E-05
Aromatics										
naphthalene		0.004		0.004	1.16E-04	9.45E-05	6.03E-05	1.27E-05	2.96E-06	8.73E-07
pyrene		0.03		0.03	1.36E-08	1.30E-08	1.14E-08	3.01E-07	2.06E-09	5.17E-10
benzo (a) pyrene	7.3		1.37E-06		5.31E-11	5.30E-11	5.25E-11	4.56E-08	1.32E-10	3.31E-11

	Risk Based Screening Level (mg/kg)											
Contaminant	Carcinogenic						Non-carcinogenic					
	Outdoors			Indoors			Outdoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9							7.78E+05	1.01E+06	1.48E+06	1.09E+04	1.21E+04	1.59E+04
C_{10} - C_{14}							1.78E+05	5.94E+05	1.90E+06	1.40E+04	1.72E+04	2.69E+04
C_{15} - C_{36}							2.18E+07	1.33E+09	5.25E+09	7.74E+07	4.84E+07	7.74E+07
MAHs												
benzene	5.36E+02	7.19E+02	1.09E+03	8.05E+00	9.02E+00	1.20E+01						
toluene							1.89E+04	3.98E+04	8.83E+04	6.53E+02	7.76E+02	1.14E+03
ethylbenzene							8.62E+03	1.93E+04	5.21E+04	3.84E+02	4.66E+02	7.11E+02
xylene							1.45E+04	3.07E+04	6.64E+04	4.91E+02	5.81E+02	8.52E+02
Aromatics												
naphthalene							3.34E+03	1.44E+04	4.88E+04	3.66E+02	4.51E+02	7.06E+02
pyrene							1.06E+06	1.55E+08	6.18E+08	2.35E+07	2.46E+07	2.80E+07
benzo (a) pyrene	1.12E+03	3.87E+05	1.54E+06	9.61E+05	9.63E+05	9.72E+05						

Table 4D2f Preliminary Health Risk Based Acceptance Criteria - Soil *Commercial/Industrial Site Use* PEATS and HIGH ORGANIC Soil Type

Site Use:	Residential	Exposure Frequency:	240 d/yr	Inhalation rate indoor:	10 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	10 m^3/d
		(non carc):	20 yr		
Target Risk:	0.00001	Exposure Dur:	20 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)					
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors			Outdoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface	>1m	>4m	Surface	>1m	>4m
Alkanes										
C_7 - C_9		5		5	9.39E-04	8.57E-04	6.79E-04	6.18E-05	2.92E-05	1.35E-05
C_{10} - C_{14}		0.3		0.3	1.02E-05	9.23E-06	7.13E-06	5.36E-06	6.26E-07	1.69E-07
C_{15} - C_{36}		1.5		1.5	1.20E-08	1.55E-08	1.20E-08	2.19E-07	1.15E-09	2.90E-10
MAHs										
benzene	0.029		3.45E-04		3.23E-04	2.95E-04	2.34E-04	2.14E-05	1.01E-05	4.64E-06
toluene		0.11		0.11	1.35E-04	1.22E-04	9.50E-05	1.98E-05	6.66E-06	2.15E-06
ethylbenzene		0.029		0.029	4.20E-05	3.79E-05	2.94E-05	1.09E-05	2.35E-06	6.84E-07
xylene		0.09		0.09	1.59E-04	1.44E-04	1.12E-04	2.16E-05	7.68E-06	2.53E-06
Aromatics										
naphthalene		0.004		0.004	5.27E-06	4.75E-06	3.67E-06	3.84E-06	3.31E-07	8.78E-08
pyrene		0.03		0.03	5.67E-10	5.31E-10	4.45E-10	5.02E-08	6.10E-11	1.53E-11
benzo (a) pyrene	7.3		1.37E-06		2.21E-12	2.20E-12	2.14E-12	5.74E-09	1.95E-12	4.87E-13

	Risk Based Screening Level (mg/kg)											
Contaminant	Carcinogenic						Non-carcinogenic					
	Outdoors			Indoors			Outdoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9							8.61E+05	1.82E+06	3.96E+06	5.67E+04	6.21E+04	7.83E+04
C_{10} - C_{14}							5.96E+05	5.10E+06	1.89E+07	3.12E+05	3.46E+05	4.48E+05
C_{15} - C_{36}							7.30E+07	1.38E+10	5.51E+10	1.33E+09	1.03E+09	1.33E+09
MAHs												
benzene	6.01E+02	1.27E+03	2.77E+03	3.98E+01	4.36E+01	5.50E+01						
toluene							5.91E+04	1.76E+05	5.45E+05	8.67E+03	9.58E+03	1.23E+04
ethylbenzene							2.83E+04	1.31E+05	4.51E+05	7.35E+03	8.14E+03	1.05E+04
xylene							4.44E+04	1.25E+05	3.79E+05	6.01E+03	6.64E+03	8.53E+03
Aromatics												
naphthalene							1.11E+04	1.28E+05	4.85E+05	8.08E+03	8.96E+03	1.16E+04
pyrene							6.36E+06	5.23E+09	2.09E+10	5.63E+08	6.02E+08	7.18E+08
benzo (a) pyrene	8.90E+03	2.62E+07	1.05E+08	2.31E+07	2.32E+07	2.38E+07						

Table 4D3a Preliminary Health Risk-Based Acceptance Criteria - Surface Soil *Residential and Agricultural Site Use* SAND Soil Type

Site Use:	Residential	Exposure Frequency:	350	d/yr	Inhalation rate indoor:	15 m^3/d
Receptor:	Adults	Averaging Time (carc):	70	yr	Inhalation rate outdoor:	20 m^3/d
		(non carc):	30	yr		
Target Risk:	0.00001	Exposure Dur:	30	yr		
Target HI:	1	Body Weight:	70	kg		

			Acceptable CDI		Volatilisation Factor (mg/m^3/mg/kg)		
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface		
Alkanes							
C_7 - C_9		5		5	1.54E-02		
C_{10} - C_{14}		0.3		0.3	6.95E-04		
C_{15} - C_{36}		1.5		1.5	1.21E-06		
MAHs							
benzene	0.029		3.45E-04		3.59E-03		
toluene		0.11		0.11	7.93E-03		
ethylbenzene		0.029		0.029	2.65E-03		
xylene		0.09		0.09	9.21E-03		
Aromatics							
naphthalene		0.004		0.004	3.35E-04		
pyrene		0.03		0.03	3.76E-08		
benzo (a) pyrene	7.3		1.37E-06		4.62E-10		

	Risk Based Screening Level (mg/kg)					
Contaminant	Carcinogenic			Non-carcinogenic		
	Indoors			Indoors		
Alkanes	Surface			Surface		
C_7 - C_9				1.58E+03		
C_{10} - C_{14}				2.10E+03		
C_{15} - C_{36}				6.06E+06		
MAHs						
benzene	1.09E+00					
toluene				6.75E+01		
ethylbenzene				5.33E+01		
xylene				4.76E+01		
Aromatics						
naphthalene				5.80E+01		
pyrene				3.89E+06		
benzo (a) pyrene	3.36E+04					

Table 4D3b
Preliminary Health Risk Based Acceptance Criteria - Surface Soil
Residential and Agricultural Site Use
Silt Soil Type

Site Use:	Residential	Exposure Frequency:	350	d/yr	Inhalation rate indoor:	15	m^3/d
Receptor:	Adults	Averaging Time (carc):	70	yr	Inhalation rate outdoor:	20	m^3/d
		(non carc):	30	yr			
Target Risk:	0.00001	Exposure Dur:	30	yr			
Target HI:	1	Body Weight:	70	kg			

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)		
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface		
Alkanes							
C_7 - C_9		5		5	1.54E-02		
C_{10} - C_{14}		0.3		0.3	6.19E-04		
C_{15} - C_{36}		1.5		1.5	1.05E-06		
MAHs							
benzene	0.029		3.45E-04		3.59E-03		
toluene		0.11		0.11	6.55E-03		
ethylbenzene		0.029		0.029	2.38E-03		
xylene		0.09		0.09	7.39E-03		
Aromatics							
naphthalene		0.004		0.004	3.07E-04		
pyrene		0.03		0.03	3.43E-08		
benzo (a) pyrene	7.3		1.37E-06		4.33E-10		

	Risk Based Screening Level (mg/kg)					
Contaminant	Carcinogenic			Non-carcinogenic		
	Indoors			Indoors		
Alkanes	Surface			Surface		
C_7 - C_9				1.58E+03		
C_{10} - C_{14}				2.36E+03		
C_{15} - C_{36}				6.96E+06		
MAHs						
benzene	1.09E+00					
toluene				8.17E+01		
ethylbenzene				5.94E+01		
xylene				5.93E+01		
Aromatics						
naphthalene				6.34E+01		
pyrene				4.26E+06		
benzo (a) pyrene	3.59E+04					

Table 4D3c Preliminary Health Risk Based Acceptance Criteria - Surface Soil *Residential and Agricultural Site Use* SILTY CLAY Soil Type

Site Use:	Residential	Exposure Frequency:	350 d/yr	Inhalation rate indoor:	15 m^3/d	
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	20 m^3/d	
		(non carc):	30 yr			
Target Risk:	0.00001	Exposure Dur:	30 yr			
Target HI:	1	Body Weight:	70 kg			

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)		
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface		
Alkanes							
C_7 - C_9		5		5	9.05E-03		
C_{10} - C_{14}		0.3		0.3	4.58E-04		
C_{15} - C_{36}		1.5		1.5	1.04E-06		
MAHs							
benzene	0.029		3.45E-04		2.24E-03		
toluene		0.11		0.11	2.61E-03		
ethylbenzene		0.029		0.029	1.32E-03		
xylene		0.09		0.09	2.80E-03		
Aromatics							
naphthalene		0.004		0.004	2.80E-04		
pyrene		0.03		0.03	3.41E-08		
benzo (a) pyrene	7.3		1.37E-06		4.32E-10		

	Risk Based Screening Level (mg/kg)					
Contaminant	Carcinogenic			Non-carcinogenic		
	Indoors			Indoors		
Alkanes	Surface			Surface		
C_7 - C_9				2.69E+03		
C_{10} - C_{14}				3.19E+03		
C_{15} - C_{36}				7.00E+06		
MAHs						
benzene	1.75E+00					
toluene				2.05E+02		
ethylbenzene				1.07E+02		
xylene				1.57E+02		
Aromatics						
naphthalene				6.95E+01		
pyrene				4.28E+06		
benzo (a) pyrene	3.60E+04					

Table 4D3d Preliminary Health Risk Based Acceptance Criteria - Surface Soil *Residential and Agricultural Site Use* CLAY Soil Type

Site Use:	Residential	Exposure Frequency:	350	d/yr	Inhalation rate indoor:	15	m^3/d
Receptor:	Adults	Averaging Time (carc):	70	yr	Inhalation rate outdoor:	20	m^3/d
		(non carc):	30	yr			
Target Risk:	0.00001	Exposure Dur:	30	yr			
Target HI:	1	Body Weight:	70	kg			

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)		
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface		
Alkanes							
C_7 - C_9		5		5	1.63E-03		
C_{10} - C_{14}		0.3		0.3	1.29E-04		
C_{15} - C_{36}		1.5		1.5	1.00E-06		
MAHs							
benzene	0.029		3.45E-04		1.45E-03		
toluene		0.11		0.11	1.69E-03		
ethylbenzene		0.029		0.029	8.60E-04		
xylene		0.09		0.09	1.77E-03		
Aromatics							
naphthalene		0.004		0.004	2.76E-04		
pyrene		0.03		0.03	3.39E-08		
benzo (a) pyrene	7.3		1.37E-06		4.30E-10		

	Risk Based Screening Level (mg/kg)					
Contaminant	Carcinogenic			Non-carcinogenic		
	Indoors			Indoors		
Alkanes	Surface			Surface		
C_7 - C_9				1.49E+04		
C_{10} - C_{14}				1.13E+04		
C_{15} - C_{36}				7.27E+06		
MAHs						
benzene	2.71E+00					
toluene				3.18E+02		
ethylbenzene				1.64E+02		
xylene				2.48E+02		
Aromatics						
naphthalene				7.06E+01		
pyrene				4.31E+06		
benzo (a) pyrene	3.61E+04					

Table 4D3e Preliminary Health Risk Based Acceptance Criteria - Surface Soil *Residential and Agricultural Site Use* PUMICE Soil Type

Site Use:	Residential	Exposure Frequency:	350 d/yr	Inhalation rate indoor:	15 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	20 m^3/d
		(non carc):	30 yr		
Target Risk:	0.00001	Exposure Dur:	30 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)		
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface		
Alkanes							
C_7 - C_9		5		5	1.38E-02		
C_{10} - C_{14}		0.3		0.3	9.50E-04		
C_{15} - C_{36}		1.5		1.5	1.83E-06		
MAHs							
benzene	0.029		3.45E-04		3.21E-03		
toluene		0.11		0.11	7.31E-03		
ethylbenzene		0.029		0.029	2.92E-03		
xylene		0.09		0.09	8.33E-03		
Aromatics							
naphthalene		0.004		0.004	3.95E-04		
pyrene		0.03		0.03	4.99E-08		
benzo (a) pyrene	7.3		1.37E-06		5.68E-10		

	Risk Based Screening Level (mg/kg)					
Contaminant	Carcinogenic			Non-carcinogenic		
	Indoors			Indoors		
Alkanes	Surface			Surface		
C_7 - C_9				1.77E+03		
C_{10} - C_{14}				1.54E+03		
C_{15} - C_{36}				4.00E+06		
MAHs						
benzene	1.22E+00					
toluene				7.32E+01		
ethylbenzene				4.83E+01		
xylene				5.25E+01		
Aromatics						
naphthalene				4.93E+01		
pyrene				2.92E+06		
benzo (a) pyrene	2.74E+04					

Table 4D3f Preliminary Health Risk Based Acceptance Criteria - Surface Soil *Residential and Agricultural Site Use* PEATS and HIGHLY ORGANIC soil type

Site Use:	Residential	Exposure Frequency:	350	d/yr	Inhalation rate indoor:	15	m^3/d
Receptor:	Adults	Averaging Time (carc):	70	yr	Inhalation rate outdoor:	20	m^3/d
		(non carc):	30	yr			
Target Risk:	0.00001	Exposure Dur:	30	yr			
Target HI:	1	Body Weight:	70	kg			

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)		
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface		
Alkanes							
C_7 - C_9		5		5	2.04E-03		
C_{10} - C_{14}		0.3		0.3	1.57E-05		
C_{15} - C_{36}		1.5		1.5	2.62E-08		
MAHs							
benzene	0.029		3.45E-04		6.90E-04		
toluene		0.11		0.11	2.12E-04		
ethylbenzene		0.029		0.029	6.47E-05		
xylene		0.09		0.09	2.52E-04		
Aromatics							
naphthalene		0.004		0.004	8.00E-06		
pyrene		0.03		0.03	8.57E-10		
benzo (a) pyrene	7.3		1.37E-06		1.08E-11		

	Risk Based Screening Level (mg/kg)					
Contaminant	Carcinogenic			Non-carcinogenic		
	Indoors			Indoors		
Alkanes	Surface			Surface		
C_7 - C_9				1.19E+04		
C_{10} - C_{14}				9.31E+04		
C_{15} - C_{36}				2.78E+08		
MAHs						
benzene	5.68E+00					
toluene				2.52E+03		
ethylbenzene				2.18E+03		
xylene				1.74E+03		
Aromatics						
naphthalene				2.43E+03		
pyrene				1.70E+08		
benzo (a) pyrene	1.44E+06					

Table 4D4a Preliminary Health Risk Based Acceptance Criteria - Surface Soil
Commercial/Industrial Site use SAND Soil Type

Site Use:	Commercial/Industrial	Exposure Frequency:	240 d/yr	Inhalation rate indoor:	10 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	10 m^3/d
		(non carc):	20 yr		
Target Risk:	0.00001	Exposure Dur:	20 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor (mg/m^3/mg/kg)		
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface		
Alkanes							
C_7 - C_9		5		5	1.02E-02		
C_{10} - C_{14}		0.3		0.3	4.53E-04		
C_{15} - C_{36}		1.5		1.5	2.35E-05		
MAHs							
benzene	0.029		3.45E-04		3.59E-03		
toluene		0.11		0.11	5.23E-03		
ethylbenzene		0.029		0.029	1.74E-03		
xylene		0.09		0.09	6.06E-03		
Aromatics							
naphthalene		0.004		0.004	2.21E-04		
pyrene		0.03		0.03	2.46E-08		
benzo (a) pyrene	7.3		1.37E-06		3.04E-10		

	Risk Based Screening Level (mg/kg)					
Contaminant	Carcinogenic			Non-carcinogenic		
	Indoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9				5.19E+03		
C_{10} - C_{14}				7.05E+03		
C_{15} - C_{36}				6.81E+05		
MAHs						
benzene	3.58E+00					
toluene				2.24E+02		
ethylbenzene				1.77E+02		
xylene				1.58E+02		
Aromatics						
naphthalene				1.93E+02		
pyrene				1.30E+07		
benzo (a) pyrene	1.68E+05					

Table 4D4b Preliminary Health Risk Based Acceptance Criteria - Surface Soil
Commercial/Industrial Site use SILt Soil Type

Site Use:	Commercial/Industrial	Exposure Frequency:	240 d/yr	Inhalation rate indoor:	10 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	10 m^3/d
		(non carc):	20 yr		
Target Risk:	0.00001	Exposure Dur:	20 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)		
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface		
Alkanes							
C_7 - C_9		5		5	1.02E-02		
C_{10} - C_{14}		0.3		0.3	4.12E-04		
C_{15} - C_{36}		1.5		1.5	2.09E-05		
MAHs							
benzene	0.029		3.45E-04		3.59E-03		
toluene		0.11		0.11	4.36E-03		
ethylbenzene		0.029		0.029	1.58E-03		
xylene		0.09		0.09	4.92E-03		
Aromatics							
naphthalene		0.004		0.004	2.05E-04		
pyrene		0.03		0.03	2.28E-08		
benzo (a) pyrene	7.3		1.37E-06		2.89E-10		

	Risk Based Screening Level (mg/kg)					
Contaminant	Carcinogenic			Non-carcinogenic		
	Indoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9				5.19E+03		
C_{10} - C_{14}				7.76E+03		
C_{15} - C_{36}				7.64E+05		
MAHs						
benzene	3.58E+00					
toluene				2.68E+02		
ethylbenzene				1.95E+02		
xylene				1.95E+02		
Aromatics						
naphthalene				2.08E+02		
pyrene				1.40E+07		
benzo (a) pyrene	1.77E+05					

Table 4D4c Preliminary Health Risk Based Acceptance Criteria - Surface Soil
Commercial/Industrial Site use SILTY CLAY Soil Type

Site Use:	Commercial/Industrial	Exposure Frequency:	240 d/yr	Inhalation rate indoor:	10 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	10 m^3/d
		(non carc):	20 yr		
Target Risk:	0.00001	Exposure Dur:	20 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)		
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface		
Alkanes							
C_7 - C_9		5		5	6.03E-03		
C_{10} - C_{14}		0.3		0.3	3.05E-04		
C_{15} - C_{36}		1.5		1.5	2.08E-05		
MAHs							
benzene	0.029		3.45E-04		1.80E-03		
toluene		0.11		0.11	1.74E-03		
ethylbenzene		0.029		0.029	8.79E-04		
xylene		0.09		0.09	1.86E-03		
Aromatics							
naphthalene		0.004		0.004	1.87E-04		
pyrene		0.03		0.03	2.27E-08		
benzo (a) pyrene	7.3		1.37E-06		2.88E-10		

	Risk Based Screening Level (mg/kg)					
Contaminant	Carcinogenic			Non-carcinogenic		
	Indoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9				8.82E+03		
C_{10} - C_{14}				1.05E+04		
C_{15} - C_{36}				7.67E+05		
MAHs						
benzene	7.15E+00					
toluene				6.73E+02		
ethylbenzene				3.51E+02		
xylene				5.14E+02		
Aromatics						
naphthalene				2.28E+02		
pyrene				1.41E+07		
benzo (a) pyrene	1.77E+05					

Table 4D4d Preliminary Health Risk Based Acceptance Criteria - Surface Soil
Commercial/Industrial Site use CLAY Soil Type

Site Use:	Commercial/Industrial	Exposure Frequency:	240 d/yr	Inhalation rate indoor:	10 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	10 m^3/d
		(non carc):	20 yr		
Target Risk:	0.00001	Exposure Dur:	20 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)		
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface		
Alkanes							
C_7 - C_9		5		5	1.09E-03		
C_{10} - C_{14}		0.3		0.3	8.58E-05		
C_{15} - C_{36}		1.5		1.5	2.01E-05		
MAHs							
benzene	0.029		3.45E-04		1.17E-03		
toluene		0.11		0.11	1.12E-03		
ethylbenzene		0.029		0.029	5.73E-04		
xylene		0.09		0.09	1.18E-03		
Aromatics							
naphthalene		0.004		0.004	1.84E-04		
pyrene		0.03		0.03	2.26E-08		
benzo (a) pyrene	7.3		1.37E-06		2.87E-10		

	Risk Based Screening Level (mg/kg)					
Contaminant	Carcinogenic			Non-carcinogenic		
	Indoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9				4.90E+04		
C_{10} - C_{14}				3.72E+04		
C_{15} - C_{36}				7.96E+05		
MAHs						
benzene	1.10E+01					
toluene				1.04E+03		
ethylbenzene				5.39E+02		
xylene				8.13E+02		
Aromatics						
naphthalene				2.32E+02		
pyrene				1.41E+07		
benzo (a) pyrene	1.78E+05					

Table 4D4e Preliminary Health Risk Based Acceptance Criteria - Surface Soil
Commercial/Industrial Site use PUMICE Soil Type

Site Use:	Commercial/Industrial	Exposure Frequency:	240 d/yr	Inhalation rate indoor:	10 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	10 m^3/d
		(non carc):	20 yr		
Target Risk:	0.00001	Exposure Dur:	20 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor ($mg/m^3/mg/kg$)		
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface		
Alkanes							
C_7 - C_9		5		5	9.17E-03		
C_{10} - C_{14}		0.3		0.3	5.89E-04		
C_{15} - C_{36}		1.5		1.5	3.32E-05		
MAHs							
benzene	0.029		3.45E-04		3.21E-03		
toluene		0.11		0.11	4.72E-03		
ethylbenzene		0.029		0.029	1.87E-03		
xylene		0.09		0.09	5.37E-03		
Aromatics							
naphthalene		0.004		0.004	2.51E-04		
pyrene		0.03		0.03	3.11E-08		
benzo (a) pyrene	7.3		1.37E-06		3.61E-10		

	Risk Based Screening Level (mg/kg)					
Contaminant	Carcinogenic			Non-carcinogenic		
	Indoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9				5.81E+03		
C_{10} - C_{14}				5.43E+03		
C_{15} - C_{36}				4.80E+05		
MAHs						
benzene	4.00E+00					
toluene				2.48E+02		
ethylbenzene				1.65E+02		
xylene				1.79E+02		
Aromatics						
naphthalene				1.70E+02		
pyrene				1.03E+07		
benzo (a) pyrene	1.41E+05					

Table 4D4f Preliminary Health Risk Based Acceptance Criteria - Surface Soil
Commercial/Industrial Site use PEATS AND HIGHLY ORGANIC Soil Type

Site Use:	Commercial/Industrial	Exposure Frequency:	240 d/yr	Inhalation rate indoor:	10 m^3/d
Receptor:	Adults	Averaging Time (carc):	70 yr	Inhalation rate outdoor:	10 m^3/d
		(non carc):	20 yr		
Target Risk:	0.00001	Exposure Dur:	20 yr		
Target HI:	1	Body Weight:	70 kg		

			Acceptable CDI		Volatilisation factor (mg/m^3/mg/kg)		
Contaminant	SF (1/mg/kg/d)	RfD (mg/kg/d)	Carcinogenic	Non-car.	Indoors		
	Inhalation	Inhalation	Inhalation	Inhalation	Surface		
Alkanes							
C_7 - C_9		5		5	1.36E-03		
C_{10} - C_{14}		0.3		0.3	1.04E-05		
C_{15} - C_{36}		1.5		1.5	5.23E-07		
MAHs							
benzene	0.029		3.45E-04		4.63E-04		
toluene		0.11		0.11	1.41E-04		
ethylbenzene		0.029		0.029	4.31E-05		
xylene		0.09		0.09	1.68E-04		
Aromatics							
naphthalene		0.004		0.004	5.33E-06		
pyrene		0.03		0.03	5.70E-10		
benzo (a) pyrene	7.3		1.37E-06		7.22E-12		

	Risk Based Screening Level (mg/kg)					
Contaminant	Carcinogenic			Non-carcinogenic		
	Indoors			Indoors		
Alkanes	Surface	>1m	>4m	Surface	>1m	>4m
C_7 - C_9				3.91E+04		
C_{10} - C_{14}				3.06E+05		
C_{15} - C_{36}				3.05E+07		
MAHs						
benzene	2.77E+01					
toluene				8.28E+03		
ethylbenzene				7.16E+03		
xylene				5.70E+03		
Aromatics						
naphthalene				7.99E+03		
pyrene				5.60E+08		
benzo (a) pyrene	7.07E+06					