

Nuvu Developments Ltd
Former Jacksons Brickworks, Ten Acres Lane
Detailed Quantitative Assessment of Risk

Rev B

December 2023

REPORT TITLE: Detailed Quantitative Assessment of Risks

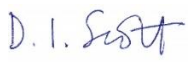
REPORT NUMBER: Rev A

CLIENT NAME: Nuvu Developments Ltd

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Document Control

Issue 1	Revision A	20/10/2023
Issue 2	Revision B – incorporating additions to reflect discussion with Laura Miller of MCC Environmental Health regarding human health risk assessment	13/12/2023

Table of Contents

1.0	Introduction.....	1
	1.1 Appointments	1
	1.2 Legal Context	1
	1.3 Document Purpose	1
	1.4 Competence.....	2
	1.5 Programme of Works	3
2.0	Proposed Development	4
	2.1 Description of Proposed Development	4
	2.2 Development Layout and Phasing	4
3.0	Post-Development Conceptual Site Model	5
	3.1 Previous Reports.....	5
	3.2 Proven Ground Conditions	6
	3.3 Future Receptors	8
	3.4 Contaminant Sources	8
	3.5 Contaminant Concentrations in Made Ground	9
	3.6 Contaminant Concentrations in Groundwater	11
	3.7 Potential Future Pathways	12
	3.8 Engineered Pathway Interruption	15
	3.9 Potential Contaminant Linkages.....	15
4.0	Risk Assessment for Human Receptors	17
	4.1 Previous Reports.....	17
	4.2 Justification for Pathway Interruption.....	17
5.0	Advective Groundwater Flow	19
	5.1 Modelling Approach	19
	5.2 Hydraulic Gradient	19
	5.3 Hydraulic Conductivity.....	22
	5.4 Effective Porosity	24
	5.5 Flow Velocity.....	24
	5.6 Compliance Point	24
	5.7 Transport Time.....	25
6.0	Contaminant Properties	26
	6.1 Contaminants of Concern	26
	6.2 Target Concentrations	26
	6.3 Soil-Water Partitioning	29
	6.4 Degradation in Groundwater.....	32
7.0	Risk Assessment for Controlled Waters.....	34
	7.1 Modelling Approach	34
	7.2 Source Concentrations	35
	7.3 Model Input Parameters – Contaminant Specific	36
	7.4 Model Input Parameters – Source Area and Hydrogeological	36
	7.5 Predicted Concentrations at Compliance Point	37
	7.6 Uncertainties.....	40
8.0	Relevant Contaminant Linkages	43
	8.1 Controlled Waters.....	43

	8.2 Future Site Users (Human Receptors)	43
	8.3 Land Stability.....	44
9.0	Conclusions and Recommendations	45
	9.1 Conclusions	45
	9.2 Recommendations	46
10.0	References	48

Appendices

Appendix A	Drawings
Appendix B	Wardell Armstrong Vapour DQRA
Appendix C	Model Outputs

1.0 Introduction

1.1 Appointments

- 1.1.1 Vertase FLI Ltd (VertaseFLI) was employed by Nuvu Developments Ltd ('the Client') to undertake pre-contract services to address the requirements of outstanding pre-commencement planning conditions associated with proposed land remediation works at the former Jackson's Brickworks, off Ten Acres Lane, Newton Heath, Manchester ('the Site'). Wardell Armstrong LLP (WA) has been employed by the Client as independent environmental consultant to oversee the land remediation works upon commencement.

1.2 Legal Context

- 1.2.1 Permission to undertake the proposed land remediation works was granted by Manchester City Council (MCC) (MCC application number 129197/FO/2021) subject to conditions. Planning conditions relevant to land contamination comprise condition 5 (site investigation), condition 6 (detailed assessment of risks), condition 7 (options appraisal and remediation strategy), and condition 9 (verification report).
- 1.2.2 The purpose of these conditions is to ensure compliance with relevant policies associated with water quality and land contamination set out in the Manchester Local Development Framework Core Strategy Development Plan published by MCC (dated 2012). These policies are understood to reflect the requirements of the National Planning Policy Framework (NPPF).
- 1.2.3 The planning permission for the proposed land remediation works is intended to enable redevelopment of the site for a mixed residential and commercial end use, which has also been granted permission by MCC (MCC application number 133700/FO/2022).

1.3 Document Purpose

- 1.3.1 The purpose of this document is to provide sufficient information to satisfy Condition 6 of Planning Permission 129197/FO/2021 granted by MCC. The wording of this condition is reproduced in paragraph 1.3.2 below:

1.3.2 *"Prior to the commencement of on-site remediation works, the applicant shall submit, for written approval, to the Local Planning Authority a detailed assessment of risks to human and environmental receptors (including those off-site). The development shall be implemented in full accordance with the details so approved."*

1.3.3 On 9th October 2023, VertaseFLI and the Client met with representatives of the Environment Agency and MCC Environmental Health. During the meeting it was agreed and accepted by all parties that there may be some residual uncertainty underpinning some of the assumptions in the current conceptual site model (CSM), which in turn underpins the detailed assessment of risks presented herein. This residual uncertainty is not unexpected given the complexity and heterogeneity of the Site. Where viable, these residual uncertainties shall be addressed by additional data collection during implementation of the remediation works (as opposed to prior to commencement of the works). The additional data shall support post-remediation risk assessment as part of the verification of the effectiveness of the remediation.

1.4 Competence

1.4.1 The Environment Agency (EA) has published guidance titled "Land Contamination Risk Management" (LCRM) which practitioners in England are expected to follow when managing risks from land contamination.

1.4.2 LCRM states that risk assessment must be undertaken by a 'Competent Person'. The contributors to the preparation of this document meet the National planning Policy Framework (NPPF) definition of 'competent person' given in Annex 2 of the NPPF, have a proven track record of dealing with land contamination and hold qualifications recognised by LCRM (Table 1-1).

Table 1-1. Evidence of competence of the report contributors

Evidence of Competence (Membership & Qualification)	Applicability to the Contributors to this Document
Membership of professional organisation relating to land contamination	Duncan Scott is a Chartered member of the Geological Society of London (CGeol and CSci) Mike Kelly is a Chartered member of the Geological Society of London (CGeol) Richard Williams is a Fellow of the Geological Society
Specialist in Land Contamination (SiLC)	Duncan Scott is a SiLC
Suitably Qualified Person (SQP) under the National Quality Mark Scheme (NQMS)	Duncan Scott is a SQP
Others	Duncan Scott is on the UK Register of Ground Engineering Professionals (RoGEP)

1.5 Programme of Works

- 1.5.1 In order to meet deadlines associated with the drawdown and use of grant funding secured for the development, it is the Client's intention for the land remediation works to commence on Site in March 2024.
- 1.5.2 As described in Section 1.1 , to support this programme, VertaseFLI has been employed under a pre-contract services agreement to address the requirements of the outstanding pre-commencement planning conditions associated with the proposed land remediation works.
- 1.5.3 As the proposed land remediation works shall aim to maximise the on-site re-use of materials, to minimise off-site disposal and maximise the sustainability of the overall scheme, all proposals with respect to the legitimate re-use of materials in the context of the Waste Framework Directive and its implementation into UK legislation and regulation shall also require agreement with the Environment Agency prior to commencement.

2.0 Proposed Development

2.1 Description of Proposed Development

2.1.1 The proposed development, of which this report seeks to discharge Condition 6 (outlined in Section 1.3), is for site remediation works (planning ref: 129197/FO/2021) in preparation for onward development.

2.1.2 The onward development which has also been granted permission by MCC (planning ref: 133700/FO/2022) comprises the following:

- Residential dwellings (houses and apartments);
- Community building with ground floor commercial floor space;
- Secondary school with associated playing fields;
- Associated car parking, highways, landscaping, community park and pocket park.

2.2 Development Layout and Phasing

2.2.1 It is currently envisaged that the site remediation will be completed in a single phase of works, planning ref: 129197/FO/2021.

2.2.2 The onward development, covered by planning ref: 133700/FO/2022, shall be constructed in two phases. Phase 1 of the development is located in the western half of the Site. Phase 2, which includes the secondary school, is located in the eastern half of the Site. A construction phasing plan and proposed development layout is included in Appendix A.

3.0 Post-Development Conceptual Site Model

3.1 Previous Reports

- 3.1.1 A significant number of previous investigations have been undertaken at the Site dating back to 2001. However, the findings of these investigations have been summarised in more recent reports prepared for the Site by WA. A summary of the WA reports and their status is given in Table 3-1.
- 3.1.2 The factual information contained within the reports prepared by WA has been used to inform the conceptual site model and quantitative assessment of risks presented herein. Where necessary, the information has been supplemented with primary data collected by VertaseFLI.

Table 3-1. Previous reports prepared by Wardell Armstrong

Date	Document Title and Status
December 2020	Outline Remediation Strategy This document was submitted in support of the Planning Application for the land remediation works (129197/FO/2021)
June 2020	Gap Analysis and Indicative Scope of Further Works This document was submitted in support of the Planning Application for the land remediation works (129197/FO/2021)
August 2022	Ten Acres Vapour Assessment (attached at Appendix B)
October 2022	Updated Combined Phase I and Phase II Ground Investigation Report. This document has previously been submitted to the Environment Agency for review under a Pre-Application Advice Service agreement for comment in the context of Condition 5 of 129197/FO/2021
October 2022	Preliminary Options Appraisal Prepared in draft only
October 2022	Preliminary Remediation Strategy Prepared in draft only
March 2023	Technical Note – Hydrogeological Conceptual Site Model Clarifications This document has previously been submitted to the Environment Agency for review under a Pre-Application Advice Service agreement for comment in the context of Condition 5 of 129197/FO/2021
April 2023	Technical Note – Deeper Ground Conditions and Laboratory Testing Clarifications This document has previously been submitted to the Environment Agency for review under a Pre-Application Advice Service agreement for comment in the context of Condition 5 of 129197/FO/2021

3.2 Proven Ground Conditions

- 3.2.1 Ground conditions beneath the Site are variable and comprise significant thicknesses of Made Ground to depths of between 0.3m up to 14.8mbgl, underlain by Glacial Till ranging in thickness from 35m to 45m, which in turn is underlain by solid geology comprising weathered sandstone of the Collyhurst Sandstone Formation and Chester Formation.
- 3.2.2 Key details relating to the proven ground conditions beneath the Site are summarised in Table 3-2.

Table 3-2. Key details relating to the ground conditions beneath the Site

Strata	Description (taken from WA reports)
Made Ground	Comprises various types of Made Ground which include: general granular soils, general cohesive soils, suspected combustion waste, suspected colliery spoil, construction and demolition waste and household waste
Glacial Till	Firm to stiff, fissured, brown, slightly sandy to sandy, gravelly clay with occasional lenses of predominantly medium dense, brown/grey gravelly clayey sand. The Glacial Till is identified to be a Secondary (Undifferentiated) Aquifer based on the BGS Aquifer Designation Map (Superficial Drift).
Weathered Sandstone of the Collyhurst Sandstone Formation	Extremely weak to weak, laminated, reddish brown, fine to coarse grained sandstone with well-rounded "millet seed" grains. The sandstone is identified to be a Principal Aquifer based on the BGS Aquifer Designation Map (Bedrock).
Weathered Sandstone of the Chester Formation	Reddish brown, fine to medium sand with black, red, white and green grains and rare angular, fine black gravel. The sandstone is identified to be a Principal Aquifer based on the BGS Aquifer Designation Map (Bedrock)

3.2.3 In addition to the proven ground conditions beneath the Site, to the south of the Site the superficial deposits are designated as a Secondary A aquifer based on BGS geological maps. The Secondary A aquifer corresponds in part with the route of the River Medlock (located circa 690m south of the Site) and comprises alluvium and late glacial flood gravels.

3.2.4 However, there is conflicting information presented within the available geological mapping with regard to the proximity to which these deposits extend towards the southwestern edge of the Site. Specifically, the BGS 1:63,360 scale drift geological map dated 1970 records sand and gravel deposits extending to within a close proximity of the southwest corner of the Site, whereas the most recent BGS geological map does not show the deposits to extend so closely to the Site. The absence of sand and gravel deposits from extending in close proximity to the south of the Site is also supported by BGS records for nearby off-site boreholes and on-site investigation data obtained by WA.

- 3.2.5 The absence of evidence led WA to conclude that the encroachment of the Secondary A aquifer up to the southwestern edge of the Site was an unsubstantiated classification that was subsequently corrected by remapping of the material as Glacial Till in the most recent version of the BGS geological map.
- 3.2.6 Notwithstanding the uncertainty with regard to the exact distance between the Site and the Secondary A aquifer located to the south of the Site, it can be concluded with certainty that an off-Site Secondary A aquifer is present, which likely provides an important source of baseflow to the River Medlock.

3.3 Future Receptors

- 3.3.1 Future receptors (which include current receptors in addition to those introduced by the proposed development) are summarised in Table 3-3.

Table 3-3. Summary of future receptors

Receptor Type	Description
Future site users	Future residents and users of the development
Future property	Buildings and building materials constructed on the Site
Controlled Waters	Groundwater in the weathered sandstone (Principal Aquifer) beneath the Site
Controlled Waters (Off-Site)	Groundwater in the Secondary A Aquifer located to the south of the Site
Controlled Waters (Off-Site)	Surface water in the Rochdale Canal located to the north of the Site
Controlled Waters (Off-Site)	Surface Water in the River Medlock located 690m to the south of the Site (which lies at approximately 60m AOD)

3.4 Contaminant Sources

- 3.4.1 Potential sources of contamination on-Site identified by WA are:
- Made Ground associated with the historical use of the Site as a brickworks.

- Made Ground associated with the historical infilling of the former brickwork's clay pits during operation of the Site as a licensed landfill.
- Made Ground used to infill a former reservoir.
- Fly tipped materials.

3.4.2 The various types of Made Ground provide a primary source of leachable contaminants with the potential to cause water pollution, degradable organic carbon with the potential to generate ground gas, and contaminants (volatile and non-volatile) with the potential to cause harm to human health and damage to buildings and building materials.

3.5 Contaminant Concentrations in Made Ground

3.5.1 Maximum contaminant concentrations measured in a dataset comprising samples of both Made Ground and natural ground by WA are provided in Table 3-4 (for inorganics) and Table 3-5 (for organics). The maximum contaminant concentrations were invariably present in the Made Ground.

Table 3-4. Summary of inorganic contaminant concentrations recorded in Made Ground by WA

Contaminant	Units	Max	UCL ₉₅
Arsenic	mg/kg	1,930	91.7
Beryllium	mg/kg	4.87	1.54
Cadmium	mg/kg	37.4	2.05
Chromium VI	mg/kg	26	1.68
Copper	mg/kg	9,990	585
Lead	mg/kg	28,700	1,360
Nickel	mg/kg	535	68.4
Zinc	mg/kg	7,290	702
Total Cyanide	mg/kg	499	20.7
Asbestos	%	5.11	0.68*

Notes:

UCL = upper confidence limit to population mean

***UCL₉₅ for asbestos has only been calculated from positive results and does not include non-detects.**

Table 3-5. Summary of organic contaminant concentrations recorded in Made Ground by WA

Contaminant	Units	Max	UCL ₉₅
Aliphatics C8-10	mg/kg	703	17.0
Aromatics >EC8-10	mg/kg	469	11.4
Aromatics >EC10-12	mg/kg	6110	154
Aromatics >EC12-16	mg/kg	5210	207
Aromatics >EC16-21	mg/kg	10900	514
Aromatics >EC21-35	mg/kg	17800	802
Aromatics >EC35-44	mg/kg	1680	86.4
Benzene	mg/kg	2.74	0.24
m-&p-Xylene	mg/kg	219	5.50
o-Xylene	mg/kg	114	2.95
Naphthalene	mg/kg	13100	341
Acenaphthylene	mg/kg	315	8.36
Acenaphthene	mg/kg	341	13.0
Fluorene	mg/kg	656	22.7
Phenanthrene	mg/kg	1550	71.3
Fluoranthene	mg/kg	1290	53.0
Pyrene	mg/kg	1120	48.9
Benzo(a)anthracene	mg/kg	432	19.7
Chrysene	mg/kg	432	18.8
Benzo(b)fluoranthene	mg/kg	461	19.0
Benzo(k)fluoranthene	mg/kg	173	7.05
Benzo(a)pyrene	mg/kg	376	16.5
Indeno(123-cd)pyrene	mg/kg	255	10.5
Dibenzo(ah)anthracene	mg/kg	51.6	2.12
Dibenzofuran	mg/kg	114	5.01
Carbazole	mg/kg	64.8	3.86
2-Methylnaphthalene	mg/kg	97.4	4.22
1,2,4-Trimethylbenzene	mg/kg	1.8	0.26
Trichloroethene	mg/kg	1.8	0.25
PCB congener 28	mg/kg	0.388	0.038
PCB congener 52	mg/kg	0.492	0.039
PCB congener 101	mg/kg	0.523	0.042
PCB congener 118	mg/kg	0.275	0.031
PCB congener 138	mg/kg	0.298	0.031
PCB congener 153	mg/kg	0.224	0.029
PCB congener 180	mg/kg	<0.150	0.024

3.6 Contaminant Concentrations in Groundwater

- 3.6.1 Maximum contaminant concentrations measured in samples of groundwater by WA are provided in Table 3-6 (for inorganics) and Table 3-7 (for organics).
- 3.6.2 The dataset from which the maximum concentration is derived includes samples of perched groundwater within the Made Ground, perched groundwater in the Glacial Till and groundwater within the bedrock beneath the Site. However, the maximum concentrations were typically recorded in within perched groundwater present in the Made Ground.

Table 3-6. Summary of inorganic contaminant concentrations recorded in groundwater by WA

Contaminant	Units	Max	UCL ₉₅
Arsenic	µg/L	35.6	9.55
Boron	µg/L	54,800	6,942
Cadmium	µg/L	11	0.91
Chromium	µg/L	10.7	3.06
Copper	µg/L	140	11.4
Lead	µg/L	13.9	2.31
Manganese	µg/L	3,880	894
Nickel	µg/L	130	14.6
Selenium	µg/L	11.8	2.07
Zinc	µg/L	54.5	16.6
Iron	µg/L	11,000	2,757
Sulphate	µg/L	807,000	255,782
Total Cyanide	µg/L	180	69.7
Thiocyanate	µg/L	120	56.8

Table 3-7. Summary of organic contaminant concentrations recorded in groundwater by WA

Contaminant	Units	Max	UCL ₉₅
TPH	µg/L	6,590	856
Naphthalene	µg/L	4.3	0.47
Fluoranthene	µg/L	19.7	3.42
Anthracene	µg/L	5.21	0.77
Benzo(b)fluoranthene	µg/L	33.2	3.49
Benzo(k)fluoranthene	µg/L	14.9	1.55
Benzo(a)pyrene	µg/L	23	2.50
Benzo(ghi)perylene	µg/L	23.2	2.13
Indeno(123-cd)pyrene	µg/L	22.1	2.10
Phenol	µg/L	370	0.064
Chloroform	µg/L	2.96	1.24
Bis(2-ethylhexyl)phthalate	µg/L	104	30.3
PFOS	µg/L	0.102	0.059
PFOS (post oxidation)	µg/L	0.129	0.079

3.7 Potential Future Pathways

3.7.1 Potential future pathways (which include current pathways in addition to those introduced by the proposed development) are summarised in Table 3-88.

Lateral Migration

3.7.2 As identified by WA in their reports, the Glacial Till deposits (which predominantly comprise low permeability cohesive materials), also contain intermittent and laterally impersistent granular lenses. The lenses, which were more frequently encountered by WA in the eastern section of the Site during their site investigation, varied in thickness between 0.05m and 12m thick (on average 2.4m thick). The granular lenses were generally composed of medium dense, brown gravelly clayey sand and were locally composed of medium dense brown sandy gravel.

3.7.3 These granular lenses within the Glacial Till have a potential significance with regard to the provision of a lateral contaminant migration pathway through the Glacial Till. However, it is assumed that the lenses are laterally discontinuous within the Glacial Till and are

therefore unlikely to provide lateral connectivity between the contamination source within the Made Ground and the downgradient Secondary A aquifer. This assumption, which is discussed further in Section 4.0, is supported by WA and indeed by earlier investigators of the Site.

Vertical Migration

3.7.4 Despite the presence of intermittent granular lenses within the Glacial Till, which may provide some localised lateral connectivity for off-site contaminant migration, vertical connectivity between granular lenses allowing downward migration of contaminants into the deeper groundwater within the Principal Aquifer is considered to have a low likelihood. Therefore, the Glacial Till is assumed to provide a natural pathway break for vertical contaminant migration. Evidence to support this is as follows:

- The presence of a significant thickness (35m to 45m) of Glacial Till overlying the Sandstone with substantial vertical intervals of low permeability cohesive materials between granular lenses within the Till.
- Contaminants of concern detected in perched groundwater within the Made Ground (heavy metals, naphthalene, anthracene, phenol, PFOS, cyanide) were not present in samples of deeper groundwater in the Sandstone obtained by WA during their site investigation.
- Groundwater levels recorded by WA within the monitoring wells installed into the Sandstone were sub-artesian (rising from 45mbgl and stabilising at an elevation within the Made Ground) and thus indicative of confined conditions within the Sandstone. Confinement of the groundwater within the Sandstone by the overlying Glacial Till is supported by research presented by the British Geological Survey (BGS) and Environment Agency for sandstone beneath the Manchester area (Griffiths et al., 2003). As a consequence of the confinement, the likelihood of hydraulic connectivity between the deeper and the shallow groundwater is low.

Lateral Migration to the Rochdale Canal

- 3.7.5 As stated previously, the granular lenses within the Glacial Till have the potential to provide a pathway by which contaminants can migrate laterally. This lateral migration is likely to follow the regional groundwater flow, south/south east, but may, due to the semi-confined nature of the granular lenses, move in other directions. Therefore, there is a possibility, although the likelihood is assumed to be low, that lateral migration of groundwater beneath the site toward the Rochdale Canal could occur.
- 3.7.6 The Rochdale Canal was constructed in the late 1790's and early 1800's. Canals at this time were generally excavated to between 4ft and 6ft (1.22m and 1.83m) and the current maximum boat draught for passage on the Rochdale Canal is 3ft 9in (1.14m). Site investigation locations along the northern boundary of the site, from WA and Celtic investigations, have recorded clay Glacial Till to depths in excess of 3m bgl. Therefore, it is considered likely that, in the absence of information with regard to an engineered liner, the canal is, at the very least, naturally clay lined. This assumption, that the canal is isolated with respect to groundwater from the site, is supported by the observation that water levels in the canal are elevated with respect to perched groundwater levels within boreholes screened within the Made Ground on site.
- 3.7.7 The Wardell Armstrong SI report indicates that contaminants recorded within surface water are, generally, not consistent with those recorded in groundwater samples from boreholes screened within the perched groundwater within Made Ground.
- 3.7.8 There is, currently, the possibility that contaminants may enter the canal through surface run-off due to the topography of the site in respect to the canal. However, this will be addressed through development of the site as site levels will be modified and the potentially contaminative surfaces will no longer be exposed.

Table 3-8. Summary of potential future pathways

Potential Future Pathway
Dissolution into groundwater (from solid)
Lateral migration through Glacial Till
Direct contact with Made Ground
Ingestion of Made Ground
Inhalation of dusts from Made Ground (indoors and outdoors)
Inhalation of vapours from Made Ground (indoors and outdoors)
Migration of explosive and asphyxiating ground gases into buildings

3.8 Engineered Pathway Interruption

3.8.1 Several engineered pathway interruption techniques are assumed to be included within the development during the construction phase. The requirement for these is based on previous human health risk assessment work undertaken by WA which is summarised in their Phase I and Phase II Site Investigation Report submitted under Condition 5. The engineered pathway interruption techniques assumed to be included are:

- Clean cover system in residential gardens and landscape areas to manage direct contact and ingestion pathways for future site users (minimum thickness of 600mm in residential gardens).
- Vapour protection measures in buildings (albeit the risk assessment underpinning the requirement for vapour protection measures shall require updating upon completion of the remediation works).
- Ground gas protection measures in buildings (in line with the appropriate Characteristic Situation for the post-remediation ground gas regime).

3.9 Potential Contaminant Linkages

3.9.1 LCRM states that the term “potential contaminant linkages” is used until the linkages are confirmed through a process of risk assessment.

3.9.2 Based on the post-development conceptual site model described in the sections above, which already accounts for engineered pathway interruption techniques implemented during the construction phase,

and given that the likelihood of vertical migration of contaminants through the Glacial Till is generally considered to be low, the only remaining potential contaminant linkage warranting further detailed assessment relates to the lateral migration of contaminants from the Site within groundwater present in the Glacial Till containing granular lenses.

- 3.9.3 The risk of pollution posed by this remaining potential contaminant linkage is considered herein for all contaminants of concern, including PFAS.

4.0 Risk Assessment for Human Receptors

4.1 Previous Reports

4.1.1 As set out within the Post-Development CSM, several engineered pathway interruption options are assumed to be implemented within the development during the construction phase (see Section 3.8). The purpose of these is to manage potentially unacceptable risks to the health of future site users and their requirement is based on previous human health risk assessment undertaken by WA in the following reports:

- WA (2022). Land Between Ten Acres Lane and Mitchell Street, Newton Heath, Manchester. Updated Combined Phase I and Phase II Ground Investigation Report. October 2022. V1.0 – this report has been submitted to address Condition 5 and Condition 6 of 129197/FO/2021 under discharge of condition application CDN/23/0731.
- WA (2022). Land Between Ten Acres Lane and Mitchell Street, Newton Heath, Manchester. Vapour Quantitative Risk Assessment. October 2022. V1.0 – this report is included in Appendix B of this report which has been submitted to address Condition 6 of 129197/FO/2021 under discharge of condition application CDN/23/0731.

4.1.2 During the meeting on 9th October 2023 between VertaseFLI, the Client and representatives of the Environment Agency and MCC Environmental Health, it was agreed with the Environmental Pollution Officer from MCC Environmental Health that the human health risk assessments in the WA reports could be used to address Condition 6 as they are based on the most recent site investigation data. Therefore, there was not a requirement for VertaseFLI to update the assessments further herein.

4.2 Justification for Pathway Interruption

4.2.1 For ease of cross reference, the risk-based justifications for the implementation of the engineered pathway interruption measures within the development during the construction phase to manage

human health risks, which are given in the WA reports, are summarised in Table 4-1 below.

Table 4-1. Summary of the risk-based justifications for the implementation of engineered pathway interruption measures to manage unacceptable risks to future site users

Pathway Interruption	Justification
Cover system in gardens and public open space (POS) areas	Site investigation data collected by WA identified concentrations of metals, PAHs, TPH CWG fractions, total cyanide, PCBs, SVOCs, VOCs, and BTEX to be present in samples of shallow Made Ground at concentrations that exceeded assessment criteria derived using the CLEA model for a generic residential exposure scenario (including the consumption of homegrown produce). Asbestos was also identified in 26 out of 129 samples. A cover system is therefore required in gardens and POS areas to break direct contact exposure pathways, which account for a significant proportion of the contaminant exposure in the standard residential exposure scenario. The thickness and composition of the cover system shall be detailed within the remediation strategy; however, the thickness shall not be less than 600mm.
Ground gas protection measures in buildings	Site investigation data collected by WA indicates that the Site has a ground gas regime in-keeping with Characteristic Situation 2 and that passive ground gas protection measures shall be required for new buildings. Notwithstanding this, the ground gas regime shall require confirmation upon completion of the proposed remediation works over a period of post-remediation monitoring.
Vapour protection measures in buildings	The assessment of risk posed by vapours undertaken by WA (see Appendix B) indicated that vapours, with the exception of a naphthalene hotspot in shallow Made Ground, are unlikely to represent an unacceptable risk to human health. This assessment was further supported by the assumption that vapour source reduction shall occur during the earthworks and remediation. However, WA highlighted that there will remain a potential for low concentrations of hydrocarbon vapours at the Site. Therefore, any membranes required to protect properties from ground gas should also be designed to ensure they are resistant to attack from vapours

5.0 Advective Groundwater Flow

5.1 Modelling Approach

5.1.1 Advection is the most important process driving the downgradient migration of dissolved contaminants in the saturated subsurface. It is the key process responsible for any migration of contaminants dissolved in perched groundwater within the Made Ground at the Site towards off-site receptors (namely the Secondary A aquifer located to the south).

5.1.2 In granular materials, the advective groundwater flow velocity is calculated from Darcy's Law (Equation 5-1), where v is the average linear groundwater flow velocity, K is the hydraulic conductivity, i is the hydraulic gradient and n_e is the effective porosity. Parameterisation of these variables is fundamental to the use of various solutions to the advection-dispersion analytical fate and transport model, which are recommended for use within the Environment Agency Remediation Targets Methodology (RTM) where applicable to the conceptual site model.

Equation 5-1

$$v = \frac{K \times i}{n_e}$$

5.2 Hydraulic Gradient

5.2.1 Current groundwater elevations within the Made Ground at the Site are complex and suggest the presence of a possible 'recharge mound' within the central portion of the landfill corresponding with the most permeable materials. In this area, groundwater elevations range up to 81 mAOD (see Drawing D1932_21A in Appendix A).

5.2.2 Off-site groundwater elevations are less well understood due to a shortage of information. The BGS borehole records identify several boreholes which have been drilled along Briscoe Lane (which lies approximately 160m southeast of the Site running parallel with the southern Site boundary) and in St Albans Avenue (also located south

of the Site) in 1987/88. These boreholes, which extend up to 8.5mbgl, frequently encounter one or more layers of sand between thicker layers of clay. Groundwater elevations measured in these boreholes are summarised in Table 5-1.

- 5.2.3 Surface water within the stretch of the River Medlock that passes to the south of the Site has an approximate elevation in the region of 61mAOD.

Table 5-1. Summary of groundwater elevations in off-site boreholes

BGS Borehole Reference	Approximate Distance from Southern Site Boundary (m)	Approximate Ground Level (mAOD)	Approximate Groundwater Elevation (mAOD)
SJ89NE956	220	75	69.5
SJ89NE957	162	79	Dry
SJ80SE1165	160	81	74.7
SD80SE1166	150	83	76.4
SD80SE1347	80	83	Not recorded

Notes:

The approximate distance of the boreholes from the southern site boundary was taken from on-line mapping tools

Ground level was not reported in the borehole records and was therefore approximated from topographic survey data

The approximate groundwater elevation was calculated based on the approximate ground level for the borehole minus the depth below ground level at which water was reported to have stabilised in the borehole records

- 5.2.4 Based on the current groundwater elevations within the Made Ground relative to the historic approximate groundwater levels within off-site boreholes (see Table 5-1) and the approximate surface water level within the River Medlock (taken to be 61 mAOD), there is the potential for a significant hydraulic head difference (and thus hydraulic gradient) to drive advective groundwater flow to the south of the Site. Example calculations of the potential hydraulic gradient are provided in Table 5-2.

Table 5-2. Example calculations of the potential hydraulic gradient based on current groundwater elevations within the Made Ground at the Site

Current Peak Groundwater Elevation in Site Made Ground (mAOD)	Groundwater Elevation Downgradient of Site (mAOD)	Approximate Distance Between Points (m)	Potential Hydraulic Gradient (m/m)
81	69.5	220	0.052
81	74.7	160	0.039
81	76.4	150	0.031
81	61.0	690	0.029

Notes:
 Potential hydraulic gradient = (current groundwater elevation in site Made Ground minus groundwater elevation in a borehole located downgradient of the Site) divided by the distance between the two points
 The head differences and hydraulic gradients are indicative only as they are based on groundwater levels recorded at different times

- 5.2.5 Notwithstanding the significant head differences, the future land remediation works and subsequent redevelopment of the Site shall inevitably reduce the elevation of the perched groundwater within the Made Ground. This is because remediation works will involve partial dewatering of the Made Ground to conduct the required earthworks to construct the formation levels and re-engineering of the Made Ground to reduce its permeability. Furthermore, the development shall reduce future infiltration into the Made Ground due to the presence of hardstanding and the requirement through Planning Condition (Condition 13 of 133700/FO/2022 for the development) to prevent surface water drainage via infiltration into the ground in areas of the Site where residual adverse concentrations of contamination are known or suspected.
- 5.2.6 Dewatering during the remediation works shall reduce the elevation of the perched groundwater within the Made Ground by a least 2m. Therefore, it is not unreasonable to assume a future peak groundwater elevation within the Made Ground at the Site of around 79mAOD. This shall reduce the potential head difference and resultant hydraulic gradient. However, a hydraulic gradient of 0.03 m/m has been assumed herein.

5.3 Hydraulic Conductivity

5.3.1 The hydraulic conductivity is the measure of an aquifer's ability to transmit water. Despite the known presence of granular lenses within the Glacial Till with a potentially high hydraulic conductivity relative to the clay, these granular lenses are assumed to be laterally discontinuous within the Till and therefore do not provide direct connectivity between contaminants present in the Made Ground and the downgradient Secondary A aquifer. Lines of evidence to support this assumption are as follows:

- The consistently elevated perched groundwater levels within the Made Ground, which have been recorded by WA and subsequently by VertaseFLI, would not be sustained over long time periods if there was significant hydraulic connectivity between the Site and the Secondary A aquifer through granular lenses within the Glacial Till. This is because interconnected granular lenses would promote rapid drainage of the Made Ground. For example, interconnected granular lenses with a hydraulic conductivity in the region of 1×10^{-3} m/s (86.4 m/day) and a cross sectional area of only 65m² (equivalent to approximately 0.1% of the surface area of the sides and base of the former clay pit) would permit a discharge of ~168m³/day (61,320 m³/year) over the hydraulic gradient. This outflow would significantly exceed the infiltration resulting from annual rainfall.
- The frequent overtopping of the former highwall of the southern (lowest) edge of the former clay pit by perched groundwater in the form of a seepage (which is currently intercepted for treatment by VertaseFLI) following periods of rainfall is further evidence that infiltration of precipitation significantly exceeds outflows via any subsurface pathways (e.g., granular lenses in the Glacial Till).
- If in direct continuity with the perched groundwater in the Site Made Ground, confined groundwater in granular lenses present in the Glacial Till at off-site locations could exhibit significant rises in level upon penetration by a borehole. However, such level rises are not reported in the records for boreholes drilled to the south

of the Site along Briscoe Road (albeit it is acknowledged that these boreholes were drilled in 1988 and the Site ceased receiving Made Ground in 1984, leaving only 4 years for the Made Ground to have become fully saturated before the off-site boreholes were drilled).

- 5.3.2 Notwithstanding the discontinuity between granular lenses present in the Glacial Till, the cohesive matrix shall still provide some lateral transmission of groundwater between the isolated granular lenses. A selection of saturated hydraulic conductivity values for the cohesive matrix within Glacial Till reported in the literature are summarised in Table 5-3.

Table 5-3. Saturated hydraulic conductivity values for Glacial Till

Hydraulic Conductivity (m/s)	Material Description	Reference
$1 \times 10^{-12} - 2 \times 10^{-6}$	Glacial Till	Wiedemeier et al., (1999)
$< 1 \times 10^{-9}$	Matrix-dominated Glacial Till with a clay content $> 35\%$	Clark (2018)
$> 1 \times 10^{-7}$	Clast-dominated Glacial Till with a clay content $< 15\%$	Clark (2018)

Notes:

See Section 10.0 for full bibliographic references

- 5.3.3 Particle size distribution (PSD) analysis for samples of the cohesive matrix of the Glacial Till was undertaken by WA and summarised in their site investigation report dated October 2022. Based on 20 samples, the clay content was reported to range from 24% - 38% with an average (mean) of 33%. Using the classification system proposed by Clark (2018) (see Table 5-3), the PSD analysis indicates that the Glacial Till is 'matrix-dominated' (as opposed to 'clast-dominated') and is likely to have a saturated hydraulic conductivity less than 1×10^{-9} m/s.
- 5.3.4 A saturated hydraulic conductivity of 1×10^{-7} m/s has been very conservatively assumed herein for the cohesive matrix of the Glacial Till.

5.4 Effective Porosity

- 5.4.1 Total porosity, θ , within the Glacial Till can be calculated using Equation 5-2, where ρ is the bulk density and ρ_s is the average particle density.

Equation 5-2

$$\theta = 1 - \left(\frac{\rho}{\rho_s} \right)$$

- 5.4.2 It is not unreasonable to assume a bulk density in the region of 1.7 Mg/m³ for the Glacial Till. Furthermore, the average particle density for clays and sands are well defined in the published literature, typically ranging from 2.65 – 2.70 Mg/m³. This would equate to a total porosity in the region of 0.36 – 0.37.
- 5.4.3 The effective porosity represents the interconnected pore space available for fluid flow. Representative values for total porosity and effective porosity for common aquifer matrix materials reported in the literature (e.g., Wiedemeier et al., 1999) demonstrate that the effective porosity is rarely above 0.3 for fine to medium sand (which corresponds with the description of the sand present in the Glacial Till). Furthermore, overall, Glacial sediments are reported to have an effective porosity not exceeding 0.2. An effective porosity of 0.3 has been conservatively adopted herein.

5.5 Flow Velocity

- 5.5.1 Based on reasonable site-specific values for the hydraulic gradient (see Section 5.2), hydraulic conductivity (see Section 5.3) and effective porosity (see Section 5.4), an upper estimate of the likely groundwater flow velocity through the Glacial Till is 0.000864 m/day (calculated using Equation 5-1).

5.6 Compliance Point

- 5.6.1 In accordance with guidance published by the Environment Agency titled "land contamination groundwater compliance points: quantitative risk assessments", where there is no specifically identifiable receptor, a default compliance point distance of 50m is recommended to protect

groundwater resources. The default compliance point distance of 50m is applicable to:

- All hazardous substances that are already in the groundwater, or that shall enter the groundwater from soils in the unsaturated zone;
- Non-hazardous pollutants in groundwater with strategic resource potential.

5.6.2 The default 50m compliance point has been adopted herein for all contaminants of concern that are identified as hazardous pollutants. For contaminants of concern identified as non-hazardous pollutants a 250m compliance point has been adopted in line with guidance for groundwater with local as opposed to strategic resource potential.

5.6.3 The default compliance points are considered conservative because the Secondary A aquifer is located significantly greater than 50m and 250m from the Site.

5.7 Transport Time

5.7.1 Over a 50m distance to a compliance point (see Section 5.6 for justification of this distance to compliance point), the un-retarded contaminant transport time would be in the region of 57,870 days (or 158 years). This would increase to 289,351 days (or 792 years) for a 250m distance.

5.7.2 By way of comparison, the un-retarded contaminant transport time to the River Medlock located circa 690m to the south of the Site is estimated to be in the region of 2,189 years.

6.0 Contaminant Properties

6.1 Contaminants of Concern

- 6.1.1 Contaminants of concern have been taken to be those measured in samples of perched groundwater samples by WA at concentrations greater than target concentrations (EQS or DWS) (see Section 3.6
- 6.1.2 PFOS has been used as a surrogate compound for all PFAS compounds. Given the nature of the potential sources of PFAS beneath the site (household waste) PFOS will potentially be the most abundant of the PFAS compounds (Environment Agency, 2019). In addition, the breadth of data and research available for PFOS in comparison to other PFAS compounds makes the selection of appropriate parameters for modelling more robust. Limitations and uncertainty around this adoption of a surrogate and PFAS in general are discussed further in Section 6.6.
- 6.1.3 Based on the age of the Made Ground (i.e., deposition completed in 1984), it is reasonable to assume that the contaminant concentrations in the perched groundwater within the Made Ground are in equilibrium with the contaminant concentrations in the solid matrix based on the infiltration scenario for the Site. Therefore, the maximum measured contaminant concentrations in the perched groundwater are likely to represent the worst-case.

6.2 Target Concentrations

- 6.2.1 Target concentrations for the contaminants of concern that are applicable at the compliance point (50m or 250m downgradient of the Site boundary) are summarised in Table 6-1 (for inorganics), Table 6-2 (for TPH fractions) and Table 6-3 (for other organics).

Table 6-1. Water quality standards used as Target Concentrations (C_T) for inorganics

Contaminant	Water Quality Standard (mg/L)	Source
Arsenic	0.01	DWS
Boron	2	EQS
Cadmium	0.00025	EQS
Chromium	0.0047	EQS
Copper	0.02146	PNEC
Lead	0.00678	PNEC
Manganese	0.17354	PNEC
Nickel	0.01216	PNEC
Selenium	0.01	DWS
Zinc	0.0302	PNEC
Iron	1	EQS
Sulphate	250	DWS
Total Cyanide	0.001	EQS
Thiocyanate	0.001	EQS

Notes:

DWS = Drinking Water Standard

EQS = Environmental Quality Standard for freshwater

PNEC = Predicted No Effect Concentration calculated by WA (River Medlock)

Table 6-2. Water quality standards used as Target Concentrations (C_T) for TPH fractions

Contaminant	Water Quality Standard (mg/L)	Source
Aliphatics C5-6	15	WHO DWS
Aliphatics C6-8	15	WHO DWS
Aliphatics C8-10	0.3	WHO DWS
Aliphatics C10-12	0.3	WHO DWS
Aliphatics C12-16	0.3	WHO DWS
Aliphatics C16-35	0.3	WHO DWS
Aromatics EC5-7	0.01	EQS
Aromatics EC7-8	0.074	EQS
Aromatics EC8-10	0.3	WHO DWS
Aromatics EC10-12	0.09	WHO DWS
Aromatics EC12-16	0.09	WHO DWS
Aromatics EC16-21	0.09	WHO DWS
Aromatics EC21-35	0.09	WHO DWS

Notes:

WHO DWS = World Health Organisation Drinking Water Standard

EQS = Environmental Quality Standard for Freshwater

Table 6-3. Water quality standards used as target concentrations (C_T) for speciated organics and PFOS

Contaminant	Water Quality Standard (mg/L)	Source
Naphthalene	0.13	EQS MAC
Fluoranthene	0.00012	EQS MAC
Anthracene	0.0001	EQS
Benzo(b)fluoranthene	0.000017	EQS MAC
Benzo(k)fluoranthene	0.000017	EQS MAC
Benzo(a)pyrene	0.00027	EQS MAC
Benzo(ghi)perylene	0.0000082	EQS MAC
Indeno(123-cd)pyrene	0.0001	DWS
Phenol	0.0077	EQS
Chloroform	0.0001	DWS
Bis(2-ethylhexyl)phthalate	0.008	DWS
PFOS	0.00005	DWI
Notes: DWI = Drinking Water Inspectorate EQS = Environmental Quality Standard MAC = Maximum Allowable Concentration		

6.3 Soil-Water Partitioning

6.3.1 Soil-water partitioning coefficients (K_d) are listed in Table 6-4 for inorganic contaminants of concern. For organic contaminants, soil-water partitioning is typically assumed to be dependent on the organic carbon in the soil (i.e., the organic carbon provides the sorption sites for the organic contaminants). Therefore, the organic carbon partition coefficients (K_{oc}) are listed in Table 6-5 for organic contaminants of concern.

Table 6-4. Soil-water partition coefficients (Kd) for inorganic contaminants of concern

Contaminant	Soil-Water Partition Coefficient (Kd)	Source
Arsenic	500	1
Boron	10	1
Cadmium	100	1
Chromium	4800	1
Copper	100	1
Lead	1000	2
Manganese	720	3
Nickel	500	1
Selenium	50	1
Zinc	38	1
Iron	810	3
Total Cyanide	5	4

Notes:

1. Nathanail et al., (2015)
2. Defra (2012)
3. ConSim
4. $K_{ow} \times 0.35$ after USEPA FIRST User Manual. K_{ow} value from EA Science Report SC040038/SR6

Table 6-5. Organic-carbon partition coefficients (Koc) for TPH fractions

Contaminant	Organic Carbon Partition Coefficient (Koc)	Source
Aliphatics C5-6	813	1
Aliphatics C6-8	3802	1
Aliphatics C8-10	30200	1
Aliphatics C10-12	239883	1
Aliphatics C12-16	5370318	1
Aliphatics C16-35	575439937	1
Aromatics EC5-7	68	1
Aromatics EC7-8	204	1
Aromatics EC8-10	1585	1
Aromatics EC10-12	2512	1
Aromatics EC12-16	5012	1
Aromatics EC16-21	14125	1
Aromatics EC21-35	125893	1

Notes:

1. Nathanail et al., (2015)

Table 6-6. Organic-carbon partition coefficients (Koc) for speciated organic contaminants of concern and PFOS

Contaminant	Organic Carbon Partition Coefficient (Koc)	Source
Naphthalene	646	1
Fluoranthene	18197	1
Anthracene	5623	1
Benzo(b)fluoranthene	104713	1
Benzo(k)fluoranthene	147911	1
Benzo(a)pyrene	128825	1
Benzo(ghi)perylene	416869	1
Indeno(123-cd)pyrene	87096	1
Phenol	29	1
Chloroform	50	1
Bis(2-ethylhexyl)phthalate	158489	2
PFOS	1000	3
Notes: 1. Nathanail et al., (2009) 2. European Chemicals Agency (ECHA) (2014) 3. Nordanstorm (2021)		

6.4 Degradation in Groundwater

- 6.4.1 Based on the age of the Made Ground contamination source, it is reasonable to assume that a population of bacteria that are capable of metabolising the organic contaminants of concern is present within the saturated zone.
- 6.4.2 Site-specific biodegradation rates for the contaminants of concern are not available. However, Table 6-7 summarises biodegradation half-lives for the contaminants which can be considered 'worst-case' in groundwater based on comprehensive published reviews of the scientific literature.
- 6.4.3 Inorganic metals and metalloids do not undergo biodegradation and therefore a biodegradation half-life of 9.9E+99 days has been assumed.

Table 6-7. Contaminant half-lives used to represent degradation in groundwater

Contaminant	Half-Life (days)	Source
Aliphatics C5-C10	500	1
Aliphatics C10-C35	1000	1
Aromatics EC5-EC10	500	1
Aromatics EC10-EC35	1000	1
Phenol	300	1
Chloroform	200	2
Bis(2-ethylhexyl)phthalate	300	3
PFOS	14965	4
Cyanide	24	5

Notes:

1. Assumed worst case values are supported by research compiled by the Environment Agency (2002)
2. Assumed worst case value supported by literature review undertaken by Aronson & Howard (1997)
3. Assumed worst case value based on literature review undertaken by the European Chemicals Agency (2014)
4. Based on a literature review undertaken by Grgas et al., (2023) which cites a half-life of PFOS in water of 41 years
5. Based on a literature review undertaken by the ATSDR (2006)

7.0 Risk Assessment for Controlled Waters

7.1 Modelling Approach

- 7.1.1 The modelling approach adopted by VertaseFLI to assess the risk of pollution of Controlled Waters is based on the Environment Agency's Remedial Targets Methodology (RTM). This methodology is applicable to historic contamination at Sites being redeveloped through the Planning Process.
- 7.1.2 The methodology, which is implemented in a series of stages termed 'Levels', uses analytical models to simulate contaminant concentration reduction as the contaminant migrates from the unsaturated soil zone, into the saturated zone and travels towards a receptor or compliance point.
- 7.1.3 The emphasis of the RTM is on the 'back-calculation' of contaminant concentrations termed "remedial targets" applicable to the source area (unsaturated soil zone or groundwater beneath the source area) at which the target contaminant concentration at the compliance point is met.
- 7.1.4 However, the approach adopted herein is to 'forward calculate' the contaminant concentration at the compliance point for direct comparison with the target concentration based on the known source concentration.
- 7.1.5 The reason for adopting a forward calculation approach is that any remediation strategy proposed for the Site is unlikely to involve full excavation of the Made Ground due to practical and economic constraints. A forward calculation approach is likely to better inform an assessment of the impact of the source term (i.e., residual contamination in the Made Ground) on downgradient groundwater quality and indeed judgements about the costs versus benefits of remediation.
- 7.1.6 The model adopted herein to represent the transport of contaminants dissolved in groundwater through the Glacial Till from the source area to the compliance point (50m or 250m downgradient from the site boundary) is the steady state Domenico equation given in the RTM (Environment Agency 2006).

- 7.1.7 The Domenico equation makes a number of simplifying assumptions about contaminant transport and attenuation within the aquifer which are considered to be conservatively applicable to the CSM. These assumptions are:
- The source is constant with time (not declining).
 - The plume has reached steady state (i.e., its maximum extent and there is no change in concentration over time).
 - Sorption to the aquifer matrix is instantaneous and can be represented by the linear sorption model.
 - The aquifer is homogenous and isotropic.
 - Groundwater flow is laminar (Darcian) and the velocity is constant.
 - For contaminants that undergo degradation, the degradation occurs in the dissolved phase only and can be represented by first-order decay rates.
 - For contaminants that undergo degradation, the metabolic by-products are harmless compounds that no longer represent a contaminant of concern.
- 7.1.8 Knowledge about the natural biological and/or chemical degradation of fluorinated compounds (i.e., PFAS) in the subsurface is still in its infancy, albeit the published literature on the subject is rapidly growing. Therefore, the latter assumption made by the Domenico equation as implemented to inform the risk assessment herein may not be applicable to PFAS. This limitation was highlighted by the Environment Agency in a meeting on 9th October 2023 and is understood and accepted by VertaseFLI. During the meeting, it was agreed that in the absence of a more specific tool for modelling the fate and transport of PFAS, the Domenico solution provides a reasonable first approximation albeit any predictions should be viewed in the context of the model limitations.
- 7.2 Source Concentrations**
- 7.2.1 Contaminant concentrations in the source area have been conservatively taken to be the maximum contaminant concentrations

recorded in groundwater by WA as part of their site investigation works during 2020 and 2022. These maximum concentrations measured in groundwater are summarised in Section 3.6 (see Table 3-6 and Table 3-7).

7.3 Model Input Parameters – Contaminant Specific

7.3.1 Contaminant specific model input parameter values are discussed in Section 6.0 with respect to soil-water partitioning and biodegradation. These parameter values have been adopted herein for the purpose of modelling.

7.4 Model Input Parameters – Source Area and Hydrogeological

7.4.1 Source area and hydrogeological model input parameter values are summarised in Table 7-1.

Table 7-1. Summary of model input parameter values

Parameter	Value	Source
Bulk density of aquifer materials (g/cm ³)	1.7	Note 1
Effective porosity (fraction)	0.3	Note 2
Hydraulic gradient (m/m)	0.03	Note 3
Hydraulic conductivity (m/day)	0.00864	Note 4
Distance to compliance point (m)	50 / 250	Note 5
Time since pollutant entered groundwater (days)	9.9E99	Note 6
Fraction of organic carbon in aquifer (fraction)	0.014	Note 7
Longitudinal dispersivity (m)	5	Note 8
Transverse dispersivity (m)	0.5	Note 9
Vertical dispersivity (m)	0.05	Note 10
Plume thickness at source (m)	18	Note 11
Width of plume at source (m)	300	Note 12

Notes:

1. Assumed value
2. See Section 5.4
3. See Section 5.2
4. See Section 5.3
5. See Section 5.6
6. Assumed to be a long time since pollutant entered groundwater so that the contaminant concentration at the compliance point (C_{ED}) is calculated when the plume has reached its maximum extent (i.e., steady state)
7. Based on an average SOM of 2.4% reported by WA for natural soils
8. Assumed to be 10% of the pathway length
9. Assumed to be 1% of the pathway length
10. Assumed to be 0.1% of the pathway length
11. Maximum depth of Made Ground on site
12. Approximate width of Made Ground that extends >3mbgl

7.5 Predicted Concentrations at Compliance Point

7.5.1 Predicted contaminant concentrations at the downgradient compliance point are summarised in Table 7-2 (for inorganics [hazardous pollutants]), Table 7-23 (for inorganics [non-hazardous pollutants]), Table 7-4 (for TPH fractions) and Table 7-5 (for other speciated organics).

- 7.5.2 The predicted concentrations for all organic contaminants and cyanide at the downgradient compliance point are significantly less than the target concentrations. This is largely due to degradation of the contaminants as they migrate very slowly through the Glacial Till, acting to reduce concentrations within a very short distance of the source area.
- 7.5.3 In contrast, the predicted concentrations of heavy metals exhibited no significant reduction between the source and the compliance point. This is because the metals do not undergo degradation and their concentration reduction is dependent upon hydrodynamic dispersion and associated dilution over the distance between the source and compliance point (50m or 250m). Hydrodynamic dispersion and associated dilution are negligible over the 50m/250m distance due to the large dimensions of the source area (assumed to be 18m thick and 300m wide).

Table 7-2. Predicted inorganic contaminant concentrations (hazardous pollutants) at the 50m compliance point

Contaminant	Predicted Concentration at 50m Compliance Point (mg/L)	Target Concentration at 50m Compliance Point (mg/L)
Arsenic	0.0356	0.01
Lead	0.0139	0.00678
Notes: See Appendix C for summary of calculations		

Table 7-3. Predicted inorganic contaminant concentrations (non-hazardous pollutants) at the 250m compliance point

Contaminant	Predicted Concentration at 250m Compliance Point (mg/L)	Target Concentration at 250m Compliance Point (mg/L)
Boron	31.74	2
Cadmium	0.0064	0.00025
Chromium	0.0062	0.0047
Copper	0.08	0.02146
Manganese	2.25	0.17354
Nickel	0.075	0.01216
Selenium	0.0068	0.01
Zinc	0.0316	0.0302
Iron	6.37	1
Total Cyanide	4.34E-125	0.001
Notes: See Appendix C for summary of calculations		

Table 7-4. Predicted TPH fraction concentrations at the 50m compliance point

Contaminant	Predicted Concentration at 50m Compliance Point (mg/L)	Target Concentration at 50m Compliance Point (mg/L)
Aliphatics C5-6	6.72E-13	15
Aliphatics C6-8	1.44E-12	15
Aliphatics C8-10	1.20E-12	0.3
Aliphatics C10-12	1.89E-08	0.3
Aliphatics C12-16	2.98E-08	0.3
Aliphatics C16-35	7.82E-07	0.3
Aromatics EC5-7	4.80E-13	0.01
Aromatics EC7-8	4.80E-13	0.074
Aromatics EC8-10	1.25E-12	0.3
Aromatics EC10-12	1.26E-08	0.09
Aromatics EC12-16	1.63E-08	0.09
Aromatics EC16-21	4.14E-08	0.09
Aromatics EC21-35	2.06E-07	0.09
Notes: See Appendix C for summary of calculations		

Table 7-5. Predicted concentrations of speciated organics at the 50m compliance point

Contaminant	Predicted Concentration at 50m Compliance Point (mg/L)	Target Concentration at 50m Compliance Point (mg/L)
Naphthalene	6.93E-10	1.30E-01
Fluoranthene	3.17E-09	1.20E-04
Anthracene	8.40E-10	1.00E-04
Benzo(b)fluoranthene	5.35E-09	1.70E-05
Benzo(k)fluoranthene	2.40E-09	1.70E-05
Benzo(a)pyrene	3.71E-09	2.70E-04
Benzo(ghi)perylene	3.74E-09	8.20E-06
Indeno(123-cd)pyrene	3.56E-09	1.00E-04
Phenol	5.16E-15	7.70E-03
Chloroform	1.19E-20	1.00E-04
Bis(2-ethylhexyl)phthalate	1.45E-15	8.00E-03
PFOS	1.13E-05	5.00E-05
Notes: See Appendix C for summary of calculations		

7.6 Uncertainties

Hydraulic Conductivity

- 7.6.1 The rationale behind the selection of the hydraulic conductivity used in the modelling is outlined in Section 4.3. However, it is accepted that there is a great deal of uncertainty with regard to hydraulic conductivity due to the nature of the ground conditions beneath the site.
- 7.6.2 In order to remove the uncertainty, it would be necessary to carry out extensive in-situ testing on discrete granular lenses across the site and within the clay Glacial Till to ascertain site specific values for hydraulic conductivity. Even after this testing has been carried out it will still be necessary to assign a value to the modelling that is representative of the ground conditions beneath the site, namely a dual porosity aquifer (predominantly clay with granular lenses).
- 7.6.3 Therefore, it would seem reasonable to adopt a conservative, literature supported value for hydraulic conductivity.

Source Dimensions

- 7.6.4 The modelled values for plume thickness and the width of the plume have been conservatively based on the approximate extents of the previously licensed landfill on site. In reality the data indicates that source areas are sporadic and potentially isolated and in many cases elevated groundwater concentrations do not coincide with a similarly elevated concentration in soil.

PFAS

- 7.6.5 There is a current lack of a risk assessment framework for PFAS and there is inherent difficulty in quantitatively risk assessing PFAS. A number of scientific papers report that the use of industry standard modelling software can be flawed when it comes to PFAS due to uncertainty around their physico-chemical properties, their complex relationship with other contaminants and the subsequent risk from breakdown/daughter products. However, due to the lack of a suitable alternative the detailed risk assessment presented herein has used the Domenic model, but it is understood that the findings should be treated with caution and further interrogation and discussion may be required.
- 7.6.6 The mechanisms and rates by which PFAS compounds undergo degradation is also an emerging topic of research and understanding. Vertase FLI research has indicated that a degradation rate of 41 years for PFOS may be appropriate but we note, again, that this should be treated with caution. This is largely due to the fact that although degradation of PFOS may take place, and is generally desirable, this will lead to the production of more mobile daughter products that may increase the size of the contaminant plume downstream and may have been previously undetected.
- 7.6.7 Sensitivity analysis of the PFOS half-life shows that the concentration of PFOS does not exceed the adopted screening criteria at the 50m compliance point until the degradation rate is increased to in excess of 50,000 days (~135 years). This is, in large part, because the maximum concentration of PFOS in the source area is relatively low (approximately 2x the target concentration). Whilst still within the possible range of PFAS half-lives reported in the literature, this goes

some way to illustrate the potential conservatism within the modelling adopted.

8.0 Relevant Contaminant Linkages

8.1 Controlled Waters

- 8.1.1 Based on the information reviewed to construct the post-development CSM (Section 3.0) and the subsequent Controlled Waters risk assessment to evaluate pollution risks to the Secondary A aquifer (Section 7.0), the only potentially 'relevant pollutant linkage' to carry forward for options appraisal relates to heavy metals, which could migrate beyond the 50m compliance point at levels above target concentrations (Section 7.0).
- 8.1.2 Due to the absence of off-site monitoring wells along the likely contaminant flow path, and indeed the conservatism underpinning the assessment, there remains uncertainty associated with this relevant pollutant linkage. Furthermore, the concentrations of some heavy metals may be naturally elevated within the Glacial Till and underlying Sandstone. For example, WA reported that the maximum measured concentrations for boron, manganese and selenium occurred within deep groundwater from the bedrock and/or perched groundwater within the Glacial Till. These maximum concentrations in the natural geology were significantly higher than those recorded in the Made Ground.
- 8.1.3 In view of these challenges associated with the heavy metals, the costs and environmental benefits of addressing any relevant pollutant linkage associated with heavy metals shall form part of the options appraisal.

8.2 Future Site Users (Human Receptors)

- 8.2.1 Based on the assumptions underpinning the post-development CSM (Section 3.0), there are no relevant pollutant linkages for future Site users to carry forward for options appraisal. However, this is because the post-development CSM already assumes the inclusion of engineered pathway interruption remediation options (see Section 3.8), which include: (1) a clean cover system in gardens and landscape areas; (2) vapour protection measures in buildings subject to further post-remediation risk assessment; and (3) ground gas protection

measures in buildings subject to post-remediation verification of the ground gas regime.

- 8.2.2 These engineered pathway interruption remediation options shall require inclusion within the options appraisal to ensure that they form part of the remediation strategy for the Site to manage risks to future site users.

8.3 Land Stability

- 8.3.1 In addition to addressing unacceptable risks to sensitive receptors posed by land contamination, the remediation options appraisal shall also consider risks posed by land stability (i.e., future settlement of the ground). In doing so, the remediation strategy shall further reduce the risk of future pollution to Controlled Waters by reducing void space and infiltration within the Made Ground (via ground improvement by excavation and re-engineering) and by removing physically unsuitable materials that influence long term land stability and may also comprise primary sources of contamination (e.g., wood, metal, plastics, fabrics).

9.0 Conclusions and Recommendations

9.1 Conclusions

- 9.1.1 The detailed quantitative assessment of risk presented herein identifies a potentially 'relevant pollutant linkage' relating to heavy metals dissolved in perched groundwater within the Made Ground that may migrate off-site through the Glacial Till beyond a 50m or 250m compliance point at levels above target concentrations. This relevant pollutant linkage shall be carried forward for further consideration at the remediation options appraisal stage.
- 9.1.2 All other potential pollutant linkages relating to Controlled Waters and future site users are considered unlikely to pose unacceptable risks in the context of the post-development CSM (subject to acceptance of the residual uncertainties that underpin key assumptions within the CSM and thus the detailed assessment of risk presented herein). These uncertainties underpinning key assumptions shall be considered further by additional ground investigation to be completed during the remediation works.
- 9.1.3 An example key assumption underpinning the CSM is that the source concentrations of contaminants within the Made Ground have been adequately characterised with depth and that the true maximum contaminant concentrations within the Made Ground is likely to have been recorded.
- 9.1.4 VertaseFLI shall propose a strategy for obtaining the additional ground investigation information within the remediation strategy and implementation plan, which is to be submitted under Planning Condition 7.
- 9.1.5 To address risks associated with land stability in the context of the proposed development, remediation works shall be required to improve the ground. These works shall also act to further reduce future risks from land contamination and to ensure that a significant betterment of groundwater quality is achieved through the development. This will be done by:

- Reducing the source of contamination to groundwater (i.e., by removing contaminant source materials that are unsuitable for retention and re-use on Site from the excavated Made Ground).
- Reducing the volume of already impacted groundwater (e.g., by partial dewatering of waste materials for ex-situ treatment and disposal).
- Reducing the future infiltration potential for rainfall into the Made Ground by re-engineering all site-won materials that are suitable for re-use as an engineered fill to construct a lower permeability development platform.

9.2 Recommendations

- 9.2.1 It has been agreed and accepted by VertaseFLI and the Environment Agency that there is some residual uncertainty underpinning some of the key assumptions in the current CSM, which in turn underpins the detailed assessment of risks presented herein. This residual uncertainty is not unexpected given the complexity and heterogeneity of the Site. Where viable, these residual uncertainties shall be addressed by additional data collection during implementation of the remediation works (as opposed to prior to commencement of the works). The additional data shall support post-remediation risk assessment as part of the verification of the effectiveness of the remediation. Details and a scope of work relating to this additional data collection undertaken during the remediation works shall be set out within the remediation strategy and implementation plan to be submitted under Planning Condition 7.
- 9.2.2 Once approved by the Local Planning Authority, the detailed risk assessment presented herein shall be used to support an options appraisal for suitable remediation measures and to develop a detailed remediation strategy which shall build on the outline remediation strategy prepared by WA to support the planning application for the remediation works.
- 9.2.3 Fundamental to the remediation strategy and the proposed development shall be the on-site re-use of excavated materials to construct the development platform. The remediation strategy shall set

out criteria that are underpinned by risk assessment to facilitate the re-use of materials outside of the waste regime on the basis that the materials are suitable for proposed use and have reached 'end of waste' status. This approach shall require agreement with the Environment Agency.

10.0 References

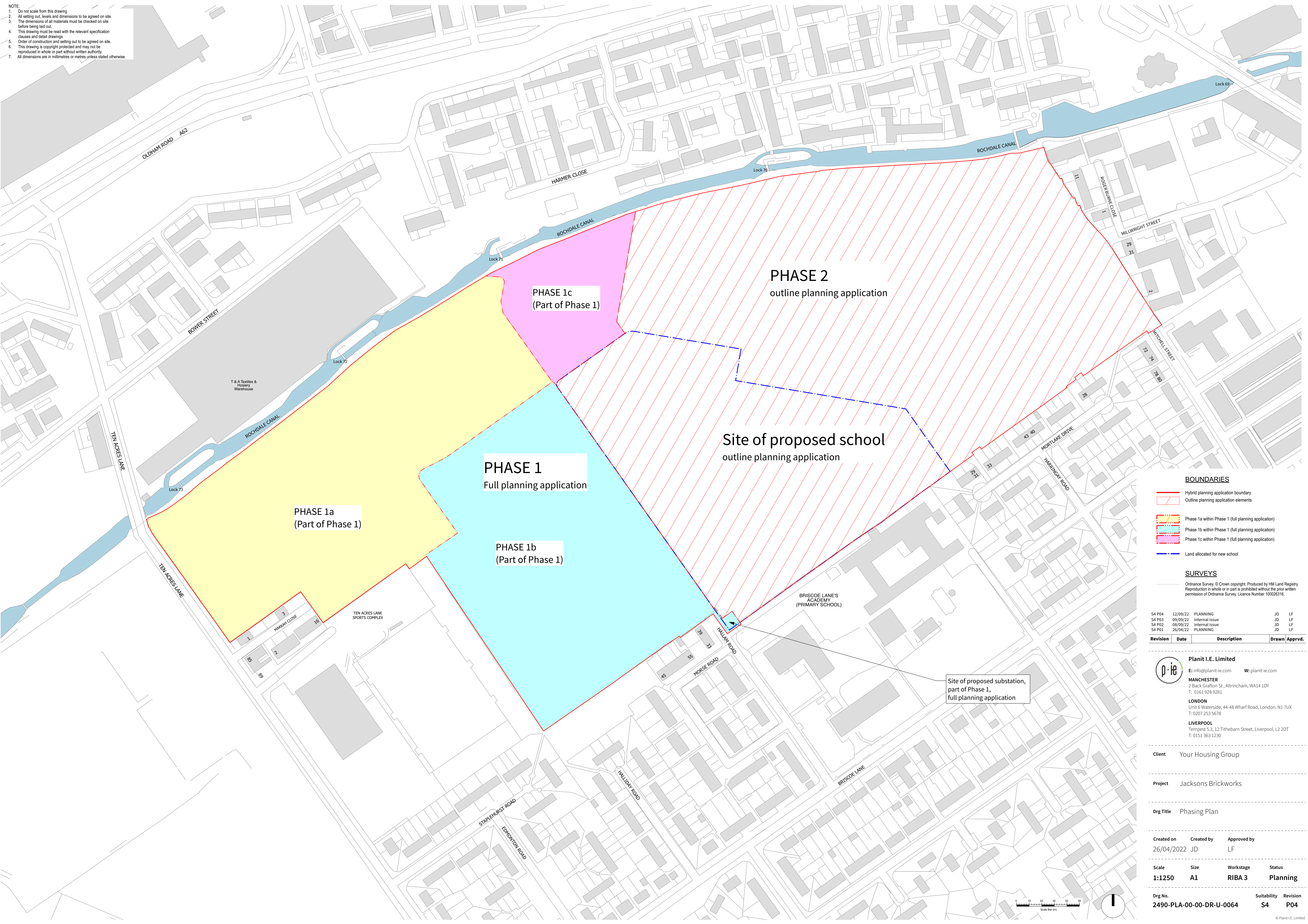
- Aronson, D. & Howard, P. H. (1997).** Anaerobic biodegradation of organic chemicals in groundwater: a summary of field and laboratory studies. Prepared by Syracuse Research Corporation for the American Petroleum Institute (API)
- ATSDR (2006).** Toxicological profile for cyanide. (Agency for Toxic Substances and Disease Registry, Atlanta)
- Clark, B. G. (2018).** The engineering properties of glacial tills. *Geotechnical Research*, 5(4), 262-277
- Defra (2014).** SP1010: Development of category 4 screening levels for assessment of land affected by contamination – policy companion document.
- Environment Agency (2002).** The effects of contaminant concentration on the potential for natural attenuation. R&D Technical Report P2-228/TR
- Environment Agency (2019).** Perfluorooctane sulfonate (PFOS) and related substances: sources, pathways and environmental data.
- European Chemicals Agency (2014).** Member state committee support document for identification of bis(2-ethylhexyl)phthalate (DEHP). Adopted on 11th December 2014
- Grgas, D., Petrina, A., Stefanac, T., Beslo, D., & Dragicevic, T. L. (2023).** A review: per- and polyfluoroalkyl substances – biological degradation. *Toxics*, 11, 446-464
- Griffiths, K. J., Shand, P. and Ingram, J. (2003).** Baseline Report Series: 8. Permo-Triassic Sandstones of the Manchester and East Cheshire. British Geological Survey Commissioned Report CR/03/265N. Environment Agency Science Group: Air, Land & Water Technical Report NC/99/74/8
- Nathanail, C. P., McCaffrey, C., Gillett, A., Ogden, R., Nathanail, J. (2015).** The LQM/CIEH S4ULs for Human Health Risk Assessment. (Land Quality Press, Nottingham)
- Nordanstorm, N. (2021).** Evaluation of distribution coefficients (Koc and Kd) for per- and polyfluoroalkyl substances. Master's Thesis. Linnaeus University, Sweden

Wiedemeier, T. H., Rifai, H. S., Newell, C. J., Wilson, J. T. (1999). Natural Attenuation of Fuels and Chlorinated Solvents in the Subsurface. (John Wiley & Sons, Chichester)

Appendix A

Drawings

NOTE:
1. Do not scale from this drawing
2. All setting out, levels and dimensions to be agreed on site
3. The dimensions of all materials must be checked on site before being laid out.
4. This drawing must be read with the relevant specification clauses and detail drawings
5. Order of construction and setting out to be agreed on site.
6. This drawing is copyright protected and may not be reproduced in whole or part without written authority.
7. All dimensions are in millimetres or metres unless stated otherwise.



BOUNDARIES

- Hybrid planning application boundary
- Outline planning application elements
- Phase 1a within Phase 1 (full planning application)
- Phase 1b within Phase 1 (full planning application)
- Phase 1c within Phase 1 (full planning application)
- Land allocated for new school

SURVEYS

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S4 P04	12/09/22	PLANNING	JD	LF
S4 P03	09/09/22	internal issue	JD	LF
S4 P02	08/09/22	internal issue	JD	LF
S4 P01	26/04/22	PLANNING	JD	LF

Revision	Date	Description	Drawn	Apprvd.
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Client Your Housing Group

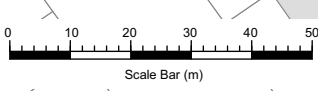
Project Jacksons Brickworks

Drg Title Phasing Plan

Created on	Created by	Approved by
26/04/2022	JD	LF

Scale	Size	Workstage	Status
1:1250	A1	RIBA 3	Planning

Drg No.	Suitability	Revision
2490-PLA-00-00-DR-U-0064	S4	P04



Jackson's Brickworks Accommodation Schedule (Phase 1_Submission Site Layout Rev D)						
Apartment Block A						
	Height	Beds	Size (m2)	Size (sq ft)	Quantity	Total Area (sq ft)
Apartment (Type 1)	3 Storey	18/2P	50.28	541.21	4	2164.833568
Apartment (Type 2)	3 Storey	28/3P	61.7	664.13	6	3984.79578
Apartment (Type 4)	3 Storey	28/4P	71.16	765.86	6	4595.744744
Apartment (Type 5)	3 Storey	28/4P	70.36	757.35	6	4544.088024
Total					22	13289.47432
Apartment Block B						
	Height	Beds	Size (m2)	Size (sq ft)	Quantity	Total Area (sq ft)
Apartment (Type 1)	3 Storey	18/2P	50.28	541.21	8	4329.671136
Apartment (Type 2)	3 Storey	28/3P	61.7	664.13	6	3984.79578
Apartment (Type 3)	3 Storey	28/3P	61.7	664.13	6	3984.79578
Apartment (Type 4)	3 Storey	28/4P	71.16	765.86	12	9191.508488
Apartment (Type 5)	3 Storey	28/4P	70.36	757.35	6	4544.088024
Total					38	26054.80021
Apartment Block C						
	Height	Beds	Size (m2)	Size (sq ft)	Quantity	Total Area (sq ft)
Apartment (Type 1)	3 Storey	18/2P	50.28	541.21	8	4329.671136
Apartment (Type 2)	3 Storey	28/3P	61.7	664.13	12	7969.59156
Apartment (Type 4)	3 Storey	28/4P	71.16	765.86	12	9191.508488
Apartment (Type 5)	3 Storey	28/3P	61.83	665.53	12	7966.38344
Total					44	29477.15543
Apartment Block D						
	Height	Beds	Size (m2)	Size (sq ft)	Quantity	Total Area (sq ft)
Apartment (Type 1)	3 Storey	18/2P	49	527.43	1	527.4311
Apartment (Type 3)	3 Storey	18/2P	50	538.29	8	4305.36
Apartment (Type 3)	3 Storey	18/2P	51	548.96	3	1646.8767
Apartment (Type 4)	3 Storey	28/3P	61	656.69	4	2626.3916
Apartment (Type 4)	3 Storey	28/3P	62	667.36	2	1334.7236
Apartment (Type 4)	3 Storey	28/4P	70	753.47	8	6027.784
Apartment (Type 4)	3 Storey	28/4P	71	764.24	4	3056.9676
Total					30	19525.7146
House types						
	Height	Beds	Size (m2)	Size (sq ft)	Quantity	Total Area (sq ft)
House type A (Main)	2 Storey	28/3P	70	753.47	7	5274.311
House type B (End)	2 Storey	28/3P	70	753.47	22	16576.466
House type C (Mid)	2 Storey	28/3P	71.2	766.39	15	11495.8452
House type D (End)	2 Storey	28/4P	83.4	897.71	10	8977.0926
House type E (Mid)	2 Storey	28/4P	83.4	897.71	5	4488.5463
House type F (End)	2 Storey	38/4P	88.2	949.38	49	46519.42302
House type G (Mid)	2 Storey	38/4P	86.2	927.85	8	7422.7844
House type H (Corner)	2 Storey	38/4P	86.2	927.85	2	1855.6936
House type I (End)	2 Storey	38/4P	93.6	1007.50	8	8060.0082
House type J (Mid)	2.5 Storey	38/5P	102.2	1100.07	46	50603.24668
House type K (Mid)	2.5 Storey	38/5P	102.9	1107.61	13	14398.86903
House type L (Mid, Premium)	3 Storey	38/6P	116	1248.61	8	9988.8892
House type M (Detached)	3 Storey	48/6P	116.2	1250.77	3	3752.29554
House type N (End)	3 Storey	48/6P	113.1	1217.40	34	41391.50106
House type O (End)	3 Storey	48/6P	147.29	1587.29	6	9523.7452
House type P (Mid)	3 Storey	48/6P	135	1453.13	6	8718.759
Total					244	250940.0399
Grand Total			378.00		341269.23	
Nett Developable Site Area			17.49 Acres		19,052.02 sq ft/Acre	
Total Site Area			4.3302			
Density			53.46pp			



The scaling of this drawing cannot be assured

Revision
Date
Dm
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LEGEND

Site Boundary (Ph1)

Amenity Grass (see Ph1 Planting Strategy)

Hedgerow/ Shrub (see Ph1 Planting Strategy)

Proposed On Plot Trees (see Ph1 Planting Strategy)

Close board fence (see Ph1 Boundary Treatment Plan)

Brick wall (see Ph1 Boundary Treatment Plan)

Weldmesh Fence (see Ph1 Boundary Treatment Plan)

Parking Space

VP
Visitor Parking Space

Disabled Parking Space

External Private Bins/Store/ Store

BCP
Bin Collection Point

320
Plot Numbers

1000mm Single Pedestrian Gate

Cycle Store

Shared Gate

Apartment Block A, B, C and D (The Hub)

Type A

Type B and C

Type D and E

Type F, G and H

Type I

Type J-K

Type L

Type M-N

Type O-P

NOTES

For a more detailed view of the landscape treatments throughout the Site, please refer to drawing:

1. Jacksons Park GA - 2490-PLA-00-00-DR-LA-0043

2. Canalside Pocket Park GA - 2490-PLA-00-00-DR-LA-0044

3. Overall Landscape GA - 2490-PLA-00-00-DR-LA-0046

4. Phase 1 Boundary Treatments - 2490-PLA-00-00-DR-LA-0050

5. Phase 1 Hardworks - 2490-PLA-00-00-DR-LA-0051

6. Phase 1 Planting Strategy - 2490-PLA-00-00-DR-LA-0052

Phase 1 Layout

Ten Acres Lane

Drawing Title
Site Layout

Date
25.04.22

Scale
1:500 @A0

Project No
32576

Drawn by
SW

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Revision
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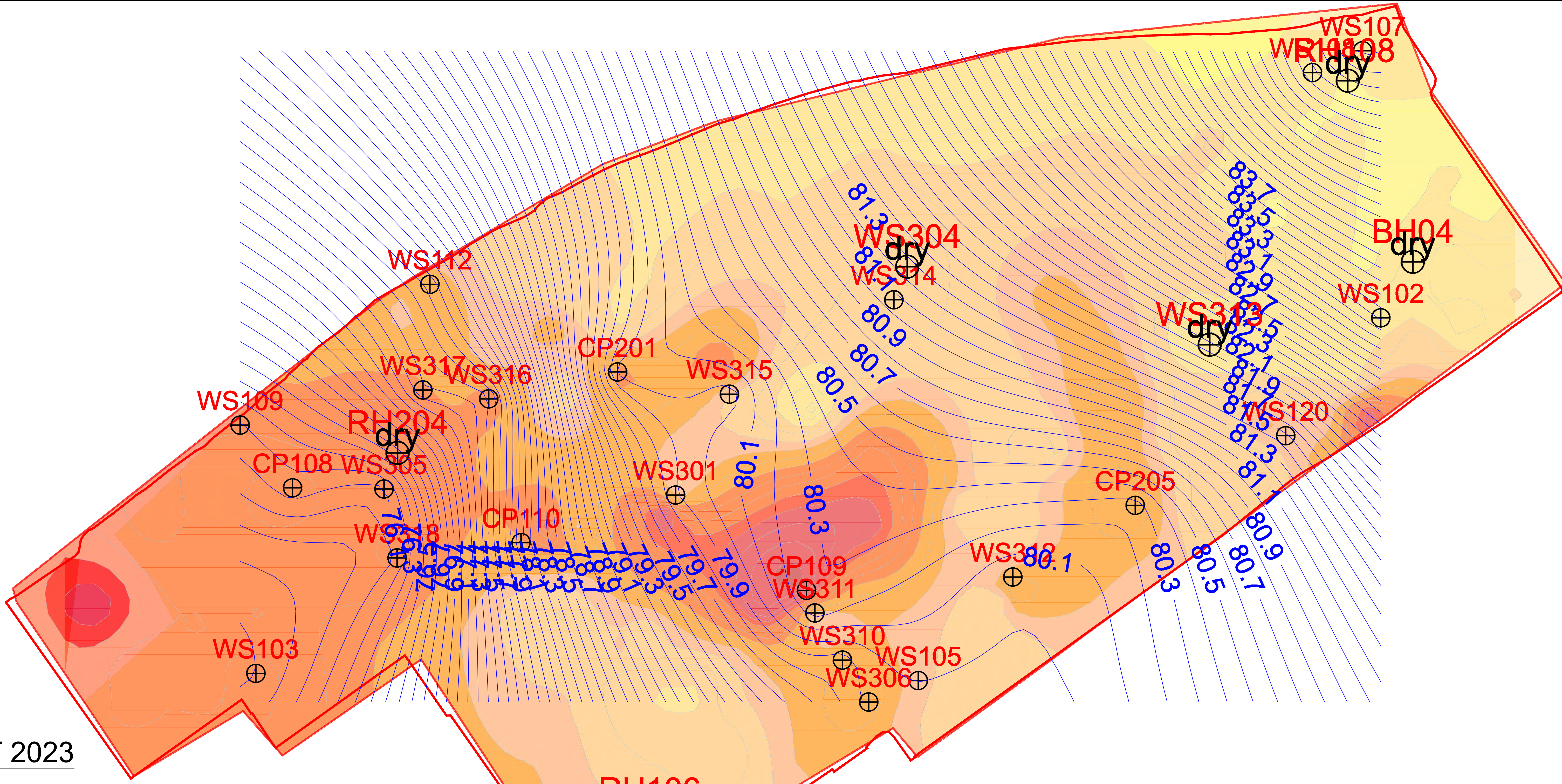
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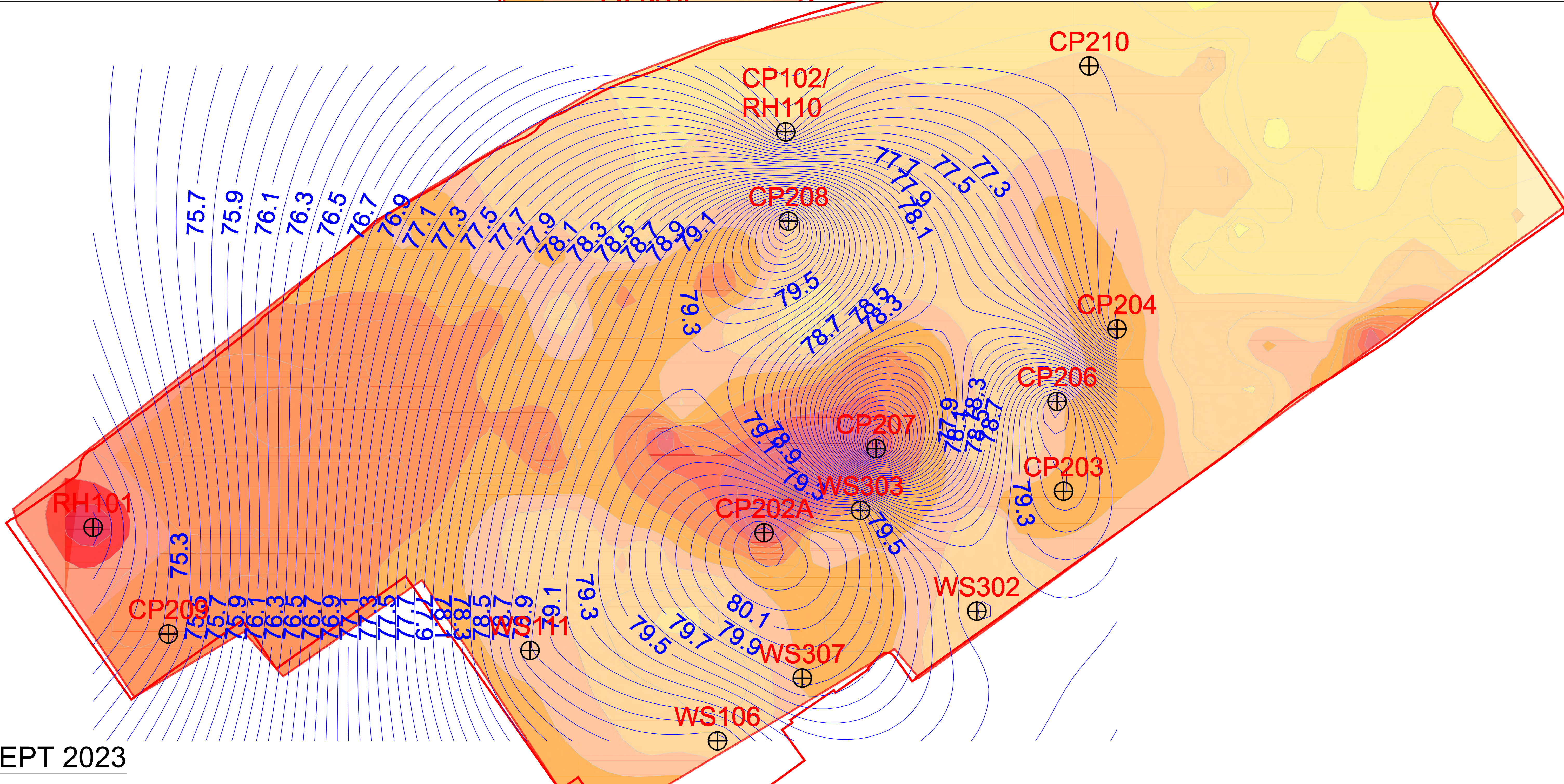
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J:\32000\32576 - Ten Acres Lane\A4 - Drawings & Registers\Masterplanning\Layout\Submission Layouts\32576-MR-M-01F - Site Layout.dwg, 25/04/2022 09:57:20, DWG To PDF.pc3



VFLI DATA MG SEPT 2023



VFLI DATA GT/NAT SEPT 2023

Key

Site Boundary

Made Ground
Depth mAOD

85
86
87
88
89

Rev. Description Revised By Date

FIRST ISSUE 19-10-2023

Vertase
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Site Address: Ten Acres Lane, Manchester, M40 2SP

Title: GW Data for Analysis - VFLI Data

Client: Your Housing Group Limited

Drawn By: JGL Checked: SE Approved: SE

Dwg No: D1832_21 Contract No: 1932YDU Scale: 1:1000

Rev. A

Appendix B

Wardell Armstrong Vapour DQRA



NUVU DEVELOPMENTS LTD

**LAND BETWEEN TEN ACRES LAND AND MITCHELL
STREET, NEWTON HEATH, MANCHESTER**

VAPOUR DETAILED QUANTITATIVE RISK ASSESSMENT

OCTOBER 2022

DATE ISSUED: October 2022
JOB NUMBER: LD10477
REPORT NUMBER: 0004
VERSION: V1.0
STATUS: Final

NUVU DEVELOPMENTS LTD

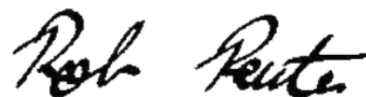
**LAND BETWEEN TEN ACRES LAND AND MITCHELL STREET, NEWTON HEATH,
MANCHESTER**

VAPOUR DETAILED QUANTITATIVE RISK ASSESSMENT

OCTOBER 2022

PREPARED BY:

Rob Reuter Associate Director



REVIEWED BY:

Sam Folarin Technical Director



APPROVED BY:

Louise Dow Regional Director



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CONTENTS

1	INTRODUCTION	1
	1.1 Instructions.....	1
	1.2 Introduction.....	1
2	Background	4
	2.1 Development History	4
	2.2 Planning.....	4
	2.3 Ground Conditions	4
	2.4 Lines of Evidence	7
3	Genric Quantitative Risk Assessment	8
	3.1 Initial Screening	8
4	Detailed Quatitative Risk Assessment	11
	4.1 Initial Modelling	11
	4.2 Further Vapour DQRA	15
5	Sensativity Analysis	19
6	Additional Considerations.....	24
	6.1 Factors of Safety.....	24
	6.2 Naphthalene Hotspot.....	25
7	Summary	27

APPENDICES

Appendix A	Indicative Made Ground Types Zoning Plan
Appendix B	CLEA Model Reports
Appendix C	WMA Worked Example
Appendix D	WMA Worksheets
Appendix E	PAH Double Ratio Plots

1 INTRODUCTION

1.1 Instructions

1.1.1 This report has been prepared in accordance with instructions issued by Nuvu Developments Ltd (via Your Housing Group Ltd) by way of email correspondence and receipt of a purchase order dated 22nd June 2022. The work follows a proposal (JC/LD10385/LET-008) dated 20th June 2022 put forward by Wardell Armstrong LLP (WA LLP).

1.2 Introduction

1.2.1 Proposals to redevelop the land between Ten Acres Lane and Mitchell Street in Newton Heath, Manchester for mixed use with a combination of residential development and a new primary school is being proposed by Nuvu Developments Limited. The approximate area of the site is shown on Figure 1 below.

Figure 1: Aerial Image Showing the Approximate Site Boundary (not to scale)
Google Earth Latest Aerial Image (2022)



1.2.2 The site has been extensively investigated and reported within a number of reports which have been used to develop the current understanding of the Conceptual Site Model (CSM). Previous reports include:

- WS Atkins Consultants Ltd: “Former Jackson Brickworks, Manchester – Desk Study Report and Preliminary Environmental Liability Assessment” – December 2001. It should be noted that this report was not available for review by Wardell Armstrong (WA), but its findings were summarised in the Celtic report below;
- Celtic Technologies Ltd: “Desk Study, Ten Acres Lane, Newton Heath, Greater Manchester” (report ref: R1077/06/2958) – July 2006;
- Celtic Technologies Ltd: “Interpretative Report, Former Jacksons Brickworks, Ten Acres Lane, Newton Heath, Greater Manchester” (report ref: R1077/08/3328) – February 2008;
- WA: “Factual Site Investigation Report, Land Between Ten Acres Lane and Mitchell Street, Newton Heath, Manchester” (report ref: SH12254 RPT-001) – July 2019;
- WA: “Outline Remediation Strategy” (report ref: JC/MP/MW/LD10162/LET-006-REV D) – dated December 2020.
- Deloitte Real Estate: “Jacksons Brickworks Redevelopment: Volume 1 (Chapter 10 – Ground Conditions)” – dated May 2022.
- WA: “Combined Phase I & Phase II Ground Investigation Report, Land Between Ten Acres Lane and Mitchell Street, Newton Heath, Manchester” (report ref: LD10162 RPT-001) – May 2021;
- WA “Ground Investigation Report – Additional Works, Land Between Ten Acres Lane and Mitchell Street, Newton Heath, Manchester” – dated September 2021; and
- WA: Updated “Combined Phase I & Phase II Ground Investigation Report, Land Between Ten Acres Lane and Mitchell Street, Newton Heath, Manchester” (report ref: LD10385/001/v1.0) – September 2022.

1.2.3 The assessments undertaken as part of the WA Updated Combined Phase I and II Ground Investigation Report (September 2022) includes all available data from the various phases of site investigations which have been undertaken by both Celtic (2007) and Wardell Armstrong (2020, 2021 & 2022). The above reports should be read in

conjunction with this report and consulted for primary data (e.g. laboratory chemical reports, exploratory hole logs etc).

- 1.2.4 The generic human health quantitative risk assessment and revised CSM presented in the WA 2022 Updated Ground Investigation Report identified contamination in the soils at the site which were considered to represent a potentially unacceptable risk to human health without mitigation. A clean cover pathway break with a minimum thickness of 600mm in residential gardens is recommended to mitigate against the risk via direct contact exposure pathways; subject to agreement with the regulators. However, a number of the contaminants have been recorded at elevated concentrations within the soils at the site and also have the potential to represent a vapour risk. This risk would not necessarily be mitigated by the use of a clean cover pathway break.
- 1.2.5 Additionally, while concentrations of potentially volatile contaminants in groundwater were identified as being relatively low, initial screening against generic assessment criteria for vapour risk (published by the Society of Brownfield Risk Assessment (SoBRA)) has indicated an exceedance. Concentrations of aliphatic TPH C₁₀ – C₁₂ in samples recovered from borehole location CP109 were recorded above the assessment criteria, indicating a potential for unacceptable vapour risk.
- 1.2.6 It is considered prudent to undertake an initial detailed quantitative risk assessment (DQRA) on contaminants where a potential vapour risk has been identified in the generic human health risk assessment

2 BACKGROUND

2.1 Development History

2.1.1 Historically, dating back to the 1890s, the site was developed as a brickworks with two large clay extraction pits shown to occupy up to 85% of the site area. Following closure of the brickworks, the pits were infilled with various types of waste from the 1940s onward, licensed to receive inert, industrial, commercial and household waste (Historical Landfill records) as well as construction & demolition waste, foundry sand, industrial non-hazardous waste, and slag and boiler / flue cleanings (Registered Landfill records). The site has remained largely derelict since the 1990s.

2.2 Planning

2.2.1 The site is understood to benefit from Full Planning Permission (reference: 129197/FO/2021) granted on 20 October 2021 for the remediation of the site. A new hybrid planning application (reference: 133700/FO/2022) has also been submitted for the comprehensive redevelopment of the site to create up to 716 dwellings, a new secondary school and a community building; all with associated car parking, highways, landscaping and new public realm creation, which is pursuant to the completion of the remediation works. Detailed design for the proposed development is not available at this time and therefore the DQRA undertaken to assess vapour risk has been completed making assumptions as to the likely type and construction of the development, which will need to be verified at detailed design stage, meaning that this assessment may require review to ascertain if the assessment remains applicable or requires re-assessment and revision.

2.3 Ground Conditions

2.3.1 The site investigation data indicates that the Made Ground at the site is multifarious in nature, heterogeneously distributed at the site, highly variable over relatively small lateral distances and layered within locations. Made Ground has been identified to depths of between 0.3m and 14.8m bgl and is underlain by Glacial Till superficial deposits to depths of between 35m and 45m bgl. The solid geology encountered at the site comprises weathered Sandstone of the Collyhurst Sandstone Formation and Chester Formation.

2.3.2 The investigations undertaken to date have identified a number of soil types encountered at the site, which are related to the natural geology present and / or the historical uses of the site. These include:

- **Topsoil Fill (TF)** – Recorded at the surface across the majority of the site typically as a soft to firm, brown, slightly sandy to sandy, slightly gravelly to gravelly Clay with frequent rootlets and occasional cobble sized fragments of red brick and concrete, that was on average 0.2m thick. Gravel sized constituents mainly included red brick and to a lesser extent concrete, timber, suspected slag / clinker, ceramic and glass. Other anthropogenic constituents were encountered locally, and this included plastic, timber, coal, slate, suspected ACM, fabric and wire.
- **Made Ground Granular (MGG) and Made Ground Cohesive (MGC)** – general Made Ground was found to be mainly granular with lower proportions of cohesive deposits encountered. The MGG was generally intermixed with other types of Made Ground and was typically recovered as a brown, sandy (ashy in places), clayey Gravel with frequent cobble and occasional boulder sized constituents locally. The MGC was also found to be generally intermixed with other types of Made Ground and was typically recovered as a soft to firm, stiff in places, brown, slightly sandy (ashy in places), slightly gravelly Clay with frequent cobble and occasional boulder sized constituents content locally. Anthropogenic inclusions in MGG / MGC included very coarse to gravel sized inclusions of red brick, concrete, sandstone, timber, ash, suspected clinker, fabrics, glass, metal, suspected slag, plastics (including bags and sheeting), ceramics, mudstone, carpet, metal, coal, slate, polystyrene, coils of wire, rubber, tyres and tile etc. with varying proportions. Hydrocarbon odours / staining were also encountered locally.
- **Made Ground, Suspected Combustion Waste (MG-CW)** – mainly encountered within the north western and to a lesser extent the south western, south eastern and north easternmost sections of the site and typically recovered as a black to brown, very sandy / ashy Gravel with a frequent cobble sized constituents. In order of decreasing abundance, the gravel and cobble sized constituents mainly comprised suspected slag and clinker, red brick, timber and to a much lesser extent inclusions of clay, glass, concrete, metal, ceramics, slate, mudstone, sandstone, tile etc. Other anthropogenic constituents such as acetate flakes, plastic bags / sheeting, white paste etc. were also noted at isolated locations. Visual and olfactory evidence of contamination in MG-CW such as hydrocarbon odours, hydrocarbon staining to soils, iridescent sheens on groundwater, red dye and tar were occasionally noted, mostly within the north western section of the site.

- **Made Ground, Suspected Colliery Spoil (MG-CS)** – occurred locally and were largely restricted to the north eastern section of the site and were typically recovered as a grey, weathered orangish brown in places, sandy, clayey Gravel with frequent cobble and boulder content. Gravel and cobble sized fragments were predominantly of mudstone and siltstone and to a lesser extent of coal, sandstone, ironstone and brick. Ash, suspected slag and suspected clinker gravel were also intermittently encountered at some of the positions.
- **Made Ground, Suspected Construction and Demolition Waste (MG – CDW)** – mainly encountered within the central section of the site and were typically recovered as cobble to boulder sized constituents of red brick, concrete, metal and timber in a matrix of brown, sandy, clayey Gravel or very gravelly, clayey Sand. In order of decreasing abundance, the other very coarse to gravel sized constituents mainly included glass, sandstone, slate, suspected slag, ash, mudstone, pipe fragments and tile etc. and to a lesser extent inclusions of plastic sheeting / bags, glass bottles, bundles of fabric, rubber, polystyrene, plastic wrappers, bundles of wire and rare tyres, paint tins, cement bags, rope etc. Visual and olfactory evidence of contamination in MG-CDW, such as hydrocarbon odours, hydrocarbon staining to soils and acrid odours, were occasionally noted.
- **Made Ground, Suspected Household Waste (MG-HW)** – mainly recorded within the central south western part of the site, but also generally intermixed with the MG - CDW within the central north western and central eastern parts of the site and typically recovered as cobble to boulder sized constituents in a matrix of brown, sandy, very clayey Gravel or very gravelly, very clayey Sand. Various anthropogenic constituents were noted and in order of decreasing abundance this included red bricks, plastics bags / sheeting, timber, glass, metal, bundles of fabric, concrete, glass bottles, rolls of carpet, ceramic, suspected slag / clinker, ash, pipe fragments, slate and rare cardboard, containers / drums, hardboard, wire, rope, flooring, polystyrene, rubber, disposable cups, toys etc. Visual and olfactory evidence of contamination in MG-HW, such as hydrocarbon odours, hydrocarbon staining to soils and water and putrid odours from shallow perched waters, were also noted.
- **Granular Glacial Till (GGT) and Cohesive Glacial Till (CGT)** – encountered beneath the entire site and predominantly comprised cohesive and to a lesser extent granular material of varying thicknesses. The CGT deposits predominantly

comprised firm to stiff (locally soft), brown, slightly gravelly, slightly sandy Clay with varied cobble and boulder content. The GGT deposits predominantly comprised loose to medium dense, brown, gravelly, clayey Sand and locally as a medium dense, brown, sandy Gravel; both of which were locally water bearing.

- 2.3.3 Please refer to the September 2022 Updated Phase I and II Ground Investigation Report for detail on the types of materials encountered during the various phases of site investigation and associated information (i.e. logs, drawings, etc). The spatial distribution of the various distinct Made Ground types is shown in Drawing LD10385-021 which is included as Appendix A.

2.4 Lines of Evidence

- 2.4.1 Site investigations undertaken at the site by Celtic and WA have included the sampling and testing of a wide range of soil and groundwater samples from the site. Additionally, a photoionisation detector (PID) was used during the site investigations to screen samples in the field. The 2021 WA additional ground investigation also included the use of an Optical Interface Probe (OIP) and a Membrane Interface Profiling tool (MIP) to attempt to delineate organic contamination and/or identify areas of potential free phase contamination. Further investigation and testing of soils and groundwater where blips were identified during the OIP and MIP testing was generally undertaken as part of the 2022 investigation. No evidence of free product, other than hydrocarbon staining and sheens on the surfaces of shallow perched water has been identified during the site investigation works. No non-aqueous phase liquids (NAPL) or free product was detected with the interface probe nor was any visual evidence of recorded during development, purging and groundwater sampling.
- 2.4.2 The data from the testing of soil and groundwater samples is the primary data source available at present. This allows the DQRA to be undertaken on a quantitative basis. It may be considered prudent to undertake additional vapour sampling and laboratory analysis as part of the detailed design to allow the initial DQRA to be refined based on actual site vapour data rather than empirically derived calculated values.

3 GENERIC QUANTITATIVE RISK ASSESSMENT

3.1 Initial Screening

3.1.1 An initial generic quantitative human health risk assessment was undertaken in relation to the results from the various phases of site investigations (where results have been compared directly with conservative published screening criteria). Without the benefit of a confirmed site masterplan, the most sensitive proposed use of residential housing with private gardens has been used for the assessment. All results have been screened against criteria for the standard residential with plant uptake end use and with values for 1% soil organic matter (SOM) used as a conservative assumption. The full results of the initial generic quantitative human health risk assessment are detailed in the September 2022 Updated Phase I and II Ground Investigation Report with the contaminants of concern (CoC) where at least one sample exceeded the conservative screening values summarised in Table 14.1.

3.1.2 Concentrations of potentially volatile CoC were detected in one or more samples at concentrations above the conservative residential with plant uptake screening values. This indicated that they potentially represent an unacceptable risk to human health in the proposed development. Table 3.1 below is a summary of the CoC and identifies where one or more samples were found to exceed the conservative screening values used in the GQRA (with the maximum concentration indicated by soil type). Full details of samples which were recorded at concentrations above the initial human health GQRA are detailed in the Exceedances Tables included as Appendix I in the September 2022 Updated Phase I and II Ground Investigation Report.

Table 3.1 – Summary of Maximum Exceedances for Potentially Volatile CoC by Soil Type									
CoC	Concentration by Soil Type (mg/kg)								
	TF	MGC	MGG	MG- CDW	MG- CS	MG- CW	MG- HW	CGT	GGT
TPH Fractions									
Aliphatic C ₈ -C ₁₀						703			
Aromatic C ₈ -C ₁₀						469			
Aromatic C ₁₀ -C ₁₂		81.1		459		6,110			
Aromatic C ₁₂ -C ₁₆		994	157	2,610		5,210			
Aromatic C ₁₆ -C ₂₁		10,900	890	8,780		2,160			
Aromatic C ₂₁ -C ₃₅		17,800	8,300	10,200		2,220			
PAH Compounds									
Naphthalene		18	102	279	3.6	13,100		30	
Acenaphthylene						315			

Table 3.1 – Summary of Maximum Exceedances for Potentially Volatile CoC by Soil Type									
CoC	Concentration by Soil Type (mg/kg)								
	TF	MGC	MGG	MG- CDW	MG- CS	MG- CW	MG- HW	CGT	GGT
Acenaphthene				341				230	
Fluorene				322		656		200	
Phenanthrene		518	98.3	1,550		1,320		590	
Fluoranthene		572		1,290		450			
Pyrene				1,120					
Benzo(a)anthracene		311	47	432		237		14	
Chrysene		237	45	432		187			
Benzo(b)fluoranthene		117	53	461		159		12	4
Benzo(k)fluoranthene		149		173					
Benzo(a)pyrene		194	39.2	376		154		9.1	2.5
Indeno(123-cd)pyrene		114	28.1	255		79.6			
Dibenzo(ah)anthracene		14.4	3.99	51.6		16.4		0.78	0.34
BTEX									
Benzene						2.74			
p/m Xylene						219			
o Xylene						114			
SVOC / VOC									
Dibenzofuran		80	13.2	114		15		81	
Carbazole		70		47.3				7.1	
2-Methylnaphthalene		180		97.4		12		19	
1,2,4-Trimethylbenzene			0.619	0.653					
2,4-Dinitrotoluene		13							
Chloromethane	0.013								
Trichloroethene				0.409	0.06				
2,4-Dimethylphenol		27							
Carbon disulphide						0.14			
Pentachlorophenol							3.35		
PCBs									
PCB-118			0.0219	0.275					
Sum EC7 PCBs			0.282	2.270					
If no value reported, all results for that CoC in that soil type were below the screening value used in the generic quantitative human health risk assessment.									

- 3.1.3 The highest concentrations of potentially volatile CoC were generally found within the suspected granular construction & demolition waste and / or suspected combustion waste types of Made Ground and were concentrated within areas within the north western, south western and north easternmost sections of the site where suspected combustion type wastes predominated. PCB 118 was the exception as the highest concentrations were generally found within the central section where suspected construction and demolition waste predominated. The general Made Ground categories (MGG and MGC) also recorded elevated concentrations, but these were generally in the same areas where they were intermixed with the Made Ground types noted above.
- 3.1.4 Lower concentrations of potentially volatile contaminants were generally more widespread (although largely concentrated within the same areas noted above) and were recorded in a variety of Made Ground types or in the underlying Glacial Till deposits where they were noted to directly underlie Made Ground (possibly reworked ground). Elevated PAH compounds are typically considered to be related to ash, slag and clinker within the suspected combustion waste types, but also elsewhere within the other Made Ground types. The majority of the exceedances have been detected in the upper 3m of the soils investigated at the site, however, these are also the soils where the investigation was more comprehensive (i.e. relating to depth of trial pits).
- 3.1.5 As noted above, groundwater from only one location was found to have concentrations of potentially volatile CoC above initial screening criteria used in the initial assessment. Groundwater from CP109 was recorded to have Aliphatic C10 – C12 TPH concentrations of 117µg/l in 2020 and 81µg/l in 2022, both of which are above the SoBRA groundwater vapour generic assessment criteria of 37µg/l and are therefore considered to represent a potential vapour risk which requires further assessment.

4 DETAILED QUANTITATIVE RISK ASSESSMENT

4.1 Initial Modelling

- 4.1.1 The risk assessments previously undertaken in relation to the results from testing of Made Ground and Glacial Till samples, discussed in the September 2022 WA Updated Phase I and II Ground Investigation Report, indicate that due to elevated concentrations of metals (arsenic, lead, nickel, beryllium, chromium VI, cadmium, copper and zinc), PAH compounds, TPHs, total cyanide, PCBs, SVOC / VOC, BTEX, PFAS. and / or asbestos fibres, a clean cover pathway break is necessary in soft landscaped areas; subject to agreement with regulators (i.e., private gardens and areas of public open space). However, CoC that could give rise to vapours and would not necessarily be fully mitigated by the required clean cover pathway break, have also been identified at elevated concentrations.
- 4.1.2 The available chemical testing results have been reviewed to identify the CoC that have the potential to represent a risk to future site users (e.g., residents) via inhalation pathways following placement of the clean cover pathway break. Concentrations of potentially volatile contaminants have been identified above conservative screening values used in the initial human health risk assessment (see Table 3.1 above for details). Therefore, it is considered appropriate to undertake further DQRA for vapour risk at the site.
- 4.1.3 The initial human health GQRA was undertaken on the conservative assumption of 1% SOM for all material types. However, across the various phases of site investigation works, SOM concentrations were also measured in the samples for each of the soil types identified and were found to be variable. Further assessment of the SOM results for each soil type has been undertaken with summary statistics for each soil type included in Table 4.1 below. Use of the lower 95th percentile confidence limit SOM value for each soil type identified is considered to be suitably conservative to derive site specific assessment criteria (SSAC) for this vapour risk assessment.

Table 4.1 – Summary of SOM Results By Soil Type					
Material Type	No. of Samples	Range	Median	Mean	Lower 95 th Percentile Confidence Limit
TF	1	37.4	NA	NA	NA
MGC	19	0.938 – 32.8	6.29	8.90	5.03
MGG	18	0.434 – 20.9	3.94	4.64	2.30
MG-CDW	27	0.759 – 46.9	5.97	9.21	5.57

Table 4.1 – Summary of SOM Results By Soil Type					
Material Type	No. of Samples	Range	Median	Mean	Lower 95 th Percentile Confidence Limit
MG-CS	1	33.3	NA	NA	NA
MG-CW	23	2.21 – 82.9	24.0	29.2	18.3
MG-HW	4	3.26 – 5.71	4.44	4.46	2.27
CGT	20	0.35 – 15.5	1.27	2.76	1.14
GGT	1	0.96	NA	NA	NA
All results in % SOM The distribution of SOM results (where a statistically significant number of results were available) were found to be log-symmetrical for all soil types and lower confidence limits were calculated in accordance with the principles of the Central Limit Theorem and the guidance in the CL:AIRE Comparing Soil Concentration Data with a Critical Concentration document. While the limited sample number for MG-HW does not support statistical analysis, the calculated Lower 95th Percentile Confidence Limit is considered to be a suitably conservative metric for use in furthermore detailed assessments as it is below the lower end of the recorded results which could otherwise be used as a representative SOM for the material type.					

4.1.4 The CLEA Model v1.07 has been used to undertake the initial DQRA process with SSAC produced for a residential end use using recommended changes to the standard model from the LQM/ CIEH S4ULs for Human Health Risk Assessment report (Table 1-3). The following two types of SSAC have been produced in the CLEA model (CLEA Reports are included in Appendix B for reference):

- Criteria to allow assessment of potential risk to site end users via all inhalation pathways. This SSAC considers both inhalation of vapours inside the proposed houses and outdoors. To produce SSAC appropriate for the assessment of each soil type identified, SSAC were produced for the following SOMs 1% (for CGT & GGT), 2.3% (for MGG & MG-HW), 5% (for MGC & MG-CDW), and 18% (for MG-CW, MG-CS and TF).
- Criteria to allow the assessment of potential risk to site end users via inhalation of vapours outdoors only, based on a conservative 1% SOM. This SSAC allows assessment of CoC identified at the site where further DQRA can illustrate that either indoor inhalation is not a significant risk and / or vapour barriers are used to sever the pathway for indoor inhalation pathways or that the vapours are located in soft landscaped areas away from buildings and / or that source reduction will be required to treat heavily impacted soils.

4.1.5 The results of this assessment are summarised in Table 4.2 below for comparison with the maximum concentrations recorded in each soil type in Table 3.1 above. Where a calculated SSAC is exceeded by a recorded concentration at the site, it has been highlighted in bold and red text for ease of reference. Further DQRA and/or mitigation will be required where recorded concentrations are above derived SSAC.

Table 4.2 – Summary of Inhalation Pathway SSAC					
CoC	SSAC Indoor and Outdoor Inhalation Pathways (mg/kg)				SSAC Outdoor Inhalation Pathways Only (mg/kg)
	1.0%	2.3%	5.0%	18%	
TPH Fractions					
Aliphatic C ₈ -C ₁₀	27	60	130	470	670,000
Aromatic C ₈ -C ₁₀	47	110	230	830	400,000
Aromatic C ₁₀ -C ₁₂	260	590	1,300	46,000	940,000
Aromatic C ₁₂ -C ₁₆	2,900	6,500	14,000	51,000	3,100,000
Aromatic C ₁₆ -C ₂₁	51,000	120,000	250,000	900,000	8,500,000
Aromatic C ₂₁ -C ₃₅	4,900,000	11,000,000	21,000,000	62,000,000	38,000,000
PAH Compounds					
Naphthalene	2.3	5.2	11	39	45,000
Acenaphthylene	4,700	11,000	23,000	82,000	18,000,000
Acenaphthene	4,900	11,000	24,000	87,000	19,000,000
Fluorene	6,200	14,000	31,000	110,000	17,000,000
Phenanthrene	7,200	17,000	36,000	130,000	8,900,000
Fluoranthene	40,000	93,000	200,000	720,000	18,000,000
Pyrene	92,000	210,000	460,000	1,700,000	4,100,000
Benzo(a)anthracene	34	78	170	600	4,800
Chrysene	350	780	1,600	5,500	8,300
Benzo(b)fluoranthene	120	270	550	1,700	1,500
Benzo(k)fluoranthene	5,100	11,000	23,000	68,000	46,000
Benzo(a)pyrene	130	290	590	1,800	1,300
Indeno(123-cd)pyrene	1,200	2,600	5,300	17,000	16,000
Dibenzo(ah)anthracene	7.1	16	34	110	160
BTEX					
Benzene	0.38	0.67	1.3	4.1	8,000
p/m Xylene	76	170	350	1,200	700,000
o Xylene	89	192	406	1,440	770,000
SVOC / VOC					
Dibenzofuran	48	110	240	870	260,000

Table 4.2 – Summary of Inhalation Pathway SSAC					
CoC	SSAC Indoor and Outdoor Inhalation Pathways (mg/kg)				SSAC Outdoor Inhalation Pathways Only (mg/kg)
	1.0%	2.3%	5.0%	18%	
Carbazole	11	24	52	190	82,000
2-Methylnaphthalene	50	110	240	880	500,000
1,2,4-Trimethylbenzene	0.58	1.3	2.8	11	27,000
2,4-Dinitrotoluene	3,700	7,300	45,000	49,000	290,000
Chloromethane	0.012	0.14	0.018	0.035	5,700
Trichloroethene	0.017	0.33	0.067	0.23	3,500
2,4-Dimethylphenol	330	700	1,500	5,100	2,600,000
Carbon disulphide	0.144	0.268	0.526	1.77	4,830
Pentachlorophenol	190	416	883	3,120	6,920
PCBs					
PCB-118	0.183	0.418	0.902	3.17	15.4
PCB Surrogate* (EC7 Sum)	0.183	0.418	0.902	3.17	15.4
* Use of PCB 118 data as a surrogate, considered conservative as PCB 118 is one of the most toxic PCBs.					

4.1.6 None of the CoC at the site have been recorded at concentrations in excess of the outdoor inhalation SSAC. Therefore, with clean cover in soft landscaped areas the concentrations of CoCs detected in the various soil types at the site are not considered to represent an unacceptable risk to human health.

4.1.7 However, the following material types were found to have one (or more) samples with a CoC concentration of above the SSAC (derived for the SOM considered representative for that material type):

- Cohesive Glacial Till (CGT) based on 1% SOM SSAC:
 - naphthalene (vapour SSAC of 2.3mg/kg) - in TP38 at 1.2m (13 - 30mg/kg), TP26 at 1.6m (5.3mg/kg) and WS102 at 2.8m (3.6mg/kg).
 - dibenzofuran (vapour SSAC of 48mg/kg)- in (81mg/kg).
- Made Ground Granular (MGG) based on 2.3% SOM:
 - naphthalene (vapour SSAC of 5.2mg/kg)– in WS109 at 3.65-3.67m (15 - 102mg/kg) and TP242 at 2.5m (8.58mg/kg).

- Made Ground Cohesive (MGC) based on 5% SOM SSAC:
 - naphthalene (vapour SSAC of 11mg/kg)– in TP8 at 2.2-2.4m (18mg/kg), TP223 at 1m (16.5mg/kg) and WS309 at 3.2m (12 - 12.3mg/kg) .
 - benzo(a)anthracene (vapour SSAC of 170mg/kg) – in WS309 at 3.2m (311mg/kg).
 - carbazole (vapour SSAC of 52mg/kg) – in TP8 at 2.2-2.4m (70mg/kg) and WS309 at 3.2m (64.8mg/kg).
- Made Ground, Suspected Construction and Demolition Waste (MG-CDW) based on 5% SOM SSAC:
 - naphthalene (vapour SSAC of 11mg/kg)– in TP117 at 4.2m (83.4 - 279mg/kg).
 - benzo(a)anthracene (vapour SSAC of 170mg/kg) – in TP117 at 4.2m (196 - 432mg/kg).
 - dibenzo(ah)anthracene (vapour SSAC of 34mg/kg) – in TP117 at 4.2m (51.6mg/kg).
 - trichloroethene (vapour SSAC of 0.067mg/kg) – in TP226 at 1.5m (0.409mg/kg)
 - PCB sum EC7 (vapour SSAC Surrogate of 0.902mg/kg) – in TP229 at 3m (2.27mg/kg).
- Made Ground, Suspected Combustion Waste (MG-CW) based on 18% SOM SSAC:
 - aliphatic C8-C10 TPH (vapour SSAC of 470mg/kg)- in TP139 at 2.4m (703mg/kg).
 - naphthalene (vapour SSAC of 39mg/kg)– in TP139 at 2.4m (13,100mg/kg).

4.2 Further Vapour DQRA

- 4.2.1 It was considered appropriate to undertake further DQRA to assess the level of risk presented by the elevated concentrations of volatile CoC that were recorded above SSAC (for indoor and outdoor inhalation calculated in the CLEA model). The Johnson and Ettinger model used within the CLEA (v1.07) model is considered overly conservative for assessment of vapour intrusion into proposed residential houses at the site. The potential for inhalation of vapours in indoor air has therefore been assessed utilizing a modular approach that allows for the incorporation of a vented sub-floor void within the foundation design. This has been done with reference to

Modular approach to analysing vapour migration into buildings in the UK by Steve Wilson (Land Contamination & Reclamation, 16 (3), 2008).

- 4.2.2 Vapour flow from the ground into the building is modelled by Johnson and Ettinger as emanating through either a perimeter drain or crack around the perimeter of the ground bearing slab and the retaining wall of the basement. Johnson and Ettinger use a pressure driven soil gas flow equation that models the effect of a basement constructed below ground level as is common in the United States. While this approach may yield a conservative estimate of vapour flow into a dwelling, in many circumstances it is considered overly conservative for modelling the situation at the site where no basements will be constructed in the dwellings. Therefore, the Wilson Modular Approach (WMA) has been adopted.
- 4.2.3 In order to model the potential flow of vapour from the residual contamination at the site to future dwellings, site specific data regarding the soils and contamination as well as assumptions as to how a slab may be constructed are required. Available site data from soil and groundwater has been used in this assessment, together with standard values from the CLEA Model for worst case soils and building types. Maximum soil concentrations were used for each assessed soil type while the maximum concentration of the CoC from groundwater recorded at the site was applied regardless of location / material type. This provides a conservative check on the significance of dissolved contamination regarding groundwater contamination. The detailed design of the development on site is not known at this stage and to ensure that the findings of this risk assessment remain appropriate, further risk assessment may be required once the houses have been designed. The purpose of this exercise is to use reasonable and conservative assumptions to assess the potential need for mitigation where a ventilated sub-floor void is incorporated into the foundation design to, inter alia, inform the need for mitigation (e.g. source reduction) during the remediation works.
- 4.2.4 Physico-chemical data for the identified CoC have been obtained from the Environment Agency (e.g. SR7 and/or appropriate tox/SGV reports), LQM/CIEH S4ULs for Human Health Risk Assessment report, The Soil Generic Assessment Criteria for Human Health Risk Assessment report prepared by EIC/CL:AIRE or alternative sources such as the US Risk Assessment Information System (for CoC not covered by UK published values). Building and soil parameters used in the modelling have been adopted from the CLEA model. The equations used to estimate vapour transfer from

the source zone to indoor air are presented within Appendix C as a worked example (with justification for each of the parameters used within the equations together with worksheets for each of the CoC). Table 4.3 below is a summary of the results of the modelling with worksheets for each CoC in each material type included in Appendix D.

Table 4.3 – Summary of WMA Modelling Results				
CoC	Maximum Concentration (mg/kg)	Inhalation Health Criteria Value – HCV_{inh} (µg/m³)	Worst Case Calculated Indoor Equilibrium Vapour Concentration - C_{building} (µg/m³)	Soil Concentration (mg/kg) Where C_{building} = HCV_{inh}
<i>Cohesive Glacial Till (CGT) based on 1.1% SOM SSAC</i>				
Naphthalene	30	2.9	0.094	920
Dibenzofuran	81	3.5	0.0012	57,000
<i>Made Ground Granular (MGG) based on 2.3% SOM</i>				
Naphthalene	102	2.9	0.16	1,800
<i>Made Ground Cohesive (MGC) based on 5.0% SOM SSAC</i>				
Naphthalene	18	2.9	0.013	4,000
Benzo(a)anthracene	311	0.0053	0.000016	120,000
Carbazole	70	18	0.0061	200,000
<i>Made Ground, Suspected Construction and Demolition Waste (MG-CDW) based on 5.5% SOM SSAC</i>				
Naphthalene	279	2.9	0.18	4,400
Benzo(a)anthracene	432	0.0053	0.0000020	13,000
Dibenzo(ah)anthracene	51.6	0.00011	0.00000077	11,000
Trichloroethene	0.409	2.0	0.039	21
PCB Sum EC7	2.27	0.23	0.000000019	28,000,000
<i>Made Ground, Suspected Combustion Waste (MG-CW) based on 18% SOM SSAC</i>				
Aliphatic C ₈ -C ₁₀ TPH	703	510	33	12,000
Naphthalene	13,100	2.9	2.7	14,000
All model results rounded to two significant figures				

- 4.2.5 The initial screening of groundwater samples against published SoBRA vapour generic assessment criteria indicated that the sole exceedance was associated with water from CP109 where concentrations of aliphatic C₁₀-C₁₂ TPH was found to be above the SoBRA GAC. The WMA approach was used to check the significance of this exceedance by using the maximum concentration recorded at CP109 (117µg/l) together with the highest soil concentration of this TPH fraction recorded anywhere on site (126mg/kg in TP139 at 2.4m). The fraction of organic carbon was set to the lowest specified in any soil types encountered (i.e. 1% SOM) and the depth to contamination was set at

1m (even though the depth of water at this location was logged as between 1.63m to 2.55m twelve rounds between November 2020 and July 2022 and the response zone was located between 9m and 13m bgl). The modelling for aliphatic C₁₀-C₁₂ TPH indicates an equilibrium indoor air concentration of 24.8µg/m³ compared to a HCV_{inh} of 510µg/m³ indicating that dissolved contamination in groundwater does not represent an unacceptable risk at the site. Modelling sheets for aliphatic C₁₀-C₁₂ TPH are also included in Appendix D.

- 4.2.6 The additional DQRA, which was undertaken using the WMA, indicates that none of the CoC are calculated to have the potential to produce an equilibrium indoor air concentration in excess of the relevant inhalation health criteria value. The soil concentration (C_R) was also changed in the model until the predicted indoor equilibrium vapour concentration was equal to the index dose / Tolerable Daily Soil Intake for each CoC. The assessment indicates that the concentrations of volatile contaminants identified at the site do not represent an unacceptable risk to the proposed residential development. However, some of the results indicate that the measured soil concentrations are close to the derived assessment criteria and sensitivity analysis on the modelling needs to be undertaken to ensure it is suitably conservative and protective of human health.

5 SENSITIVITY ANALYSIS

5.1.1 A sensitivity analysis has been undertaken on the naphthalene WMA model in relation to the suspected combustion waste material. Naphthalene was selected for assessment as it was by far the highest level of volatile contamination identified at the site. The sensitivity analysis checks that the input parameters are representative of site conditions and suitably conservative. Each of the parameters in the model was changed independently by a factor of +/- 10% to record the resultant impact on the modelled equilibrium concentration of naphthalene vapour in indoor air (C_{building}). The results of this sensitivity analysis are presented in Table 5.1 below.

Table 5.1 – Sensitivity Analysis Summary

Input Parameter	Originally Modelled			90% original (-10% change)			110% original (+10% change)		
	Symbol	Value	Units	Value	C _{building}	% diff.	Value	C _{building}	% diff.
Soil Concentration	C _R	13100	mg/kg	11790	2.46	90.0%	14410	3.00	110.0%
Soil dry bulk density	ρ _b	1.18	g/cm ³	1.06	2.73	100.0%	1.29800	2.73	100.0%
Dimensionless Henry's Law constant (or Kaw)	H' _{TS}	0.00662	-	0.00596	2.46	90.1%	0.00728	3.00	109.9%
Soil air filled porosity	Θ _α	0.3	cm ³ /cm ³	0.27	2.16	79.1%	0.33	3.36	123.1%
Soil water filled porosity	Θ _ω	0.24	cm ³ /cm ³	0.216	2.99	109.4%	0.264	2.51	91.8%
Octanol-water partition coefficient	K _{oc}	646	cm ³ /g	581	3.03	111.1%	710	2.48	90.9%
Soil fraction organic carbon	f _{oc}	0.1	-	0.09	3.03	111.1%	0.11	2.48	90.9%
Groundwater concentration	C _w	4.3	μg/l	3.87	2.73	100.0%	4.73	2.73	100.0%
Floor Area	A _B	2.80E+05	cm ²	252000	3.03	111.1%	308000	2.48	90.9%
Vapour conc. at top of soil*	C _{g0}	0.00E+00	g/cm ³	NA			3.00E-13	2.73	100.0%
Diffusion coefficient in air	D _{air}	6.52E-02	cm ² /s	0.0587	2.46	90.1%	0.0717	3.00	109.9%
Diffusion coefficient in water	D _{water}	5.16E-06	cm ² /s	4.64E-06	2.73	99.9%	5.68E-06	2.73	100.1%
Depth to Source	L	60	cm	54	3.03	111.1%	66	2.48	90.9%
Air Exchanges in Void	V _{ex}	1	1/day	0.9	3.03	111.1%	1.1	2.48	90.9%
Void Height	H _{void}	150	cm	135	3.03	111.1%	165	2.48	90.9%
Vapour conc. in outdoor air*	C _e	0.00E+00	g/cm ³	NA			3.00E-13	3.03	111.0%
Pressure difference	ΔP	3.1	Pa	2.79	2.46	90.0%	3.41	3.00	110.0%
Intrinsic permeability of floor slab	k _v	2.00E-07	cm ²	1.80E-07	2.46	90.0%	2.20E-07	3.00	110.0%
Area of cracks in floor slab	A _{crack}	423.3	cm ²	381	2.46	90.0%	465.63	3.00	110.0%
Viscosity of air	μ	1.80E-05	Pa s	1.62E-05	3.03	111.1%	1.98E-05	2.48	90.9%

Table 5.1 – Sensitivity Analysis Summary									
Input Parameter	Originally Modelled			90% original (-10% change)			110% original (+10% change)		
	Symbol	Value	Units	Value	C _{building}	% diff.	Value	C _{building}	% diff.
thickness of floor slab	D _{crack}	15	cm	13.5	3.03	111.1%	16.5	2.48	90.9%
Air exchange rate in building	B _{ex}	0.5	1/hr	0.45	3.03	111.1%	0.55	2.48	90.9%
Building height	H	480	cm	432	3.03	111.1%	528	2.48	90.9%
Model Output									
Calculated Indoor Vapour Concentration	C _{building}	2.73	mg/m ³						
* The naphthalene concentration at the top of the soil and in outdoor air was assumed to be zero in the initial modelling and therefore could not be altered by 10%. Background naphthalene outdoor air concentrations from a 1999/2000 study in Birmingham reported on in Jia and Batterman 2010 (A critical review of Naphthalene Sources and Exposures Relevant to Indoor and Outdoor Air, Int. J. Environ. Res. Public Health 2010, 7, 2903-2939) of 3 x 10 ⁻¹³ g/cm ³ used in assessment.									

- 5.1.2 The completed sensitivity analysis indicates that most parameters are generally either directly proportional (i.e. that a change in the parameter value equates to a change of the same order in the model output) or indirectly proportional (i.e. that a change in the parameter value equates to a change of the same order but in the opposite direction in the model output). Parameters that are generally proportional include; the soil concentration, Henry's Law constant, diffusion coefficient in air, pressure difference (between outside and the building), intrinsic permeability of the floor slab and the area of cracks in the slab. Those which are generally inversely proportional include; the soil water filled porosity, octanol-water partition coefficient, soil fraction of organic carbon, depth to source, air exchanges in void, void height, viscosity of air, thickness of floor slab, air exchange rate in building and building height.
- 5.1.3 A number of parameters do not have an impact on the model output for naphthalene in combustion waste, including soil bulk density, the groundwater concentration (because it is relatively negligible compared to the high soil concentration), vapour concentration at the top of soil and / or the diffusion coefficient in water. However, the soil air filled porosity and the vapour concentration in outdoor air are deemed to have a potentially greater impact to the model than other factors.
- 5.1.4 Without confirmation of the design of buildings on site, choice of published values by the EA for a small, terraced house with a sub-floor void as used in the CLEA model are considered appropriate. The physico-chemical data recommended by the EA in SR7 for naphthalene are also considered appropriate for the modelling. Additionally, the modelling undertaken is regarded as conservative for the following reasons:
- An air exchange in the void of only one per day has been used in the modelling. Construction of the void venting in line with NHBC minimum standards of 1,500mm²/m run on at least 2 sides would equate to a venting rate of circa 8 exchanges per day when the principles of BS5925 are applied. This parameter is inversely proportional and would equate to a decrease in the calculated indoor naphthalene vapour concentration.
 - The maximum concentration of naphthalene in soil recorded at TP139 at 2.4m of 13,100mg/kg has been modelled. This concentration is by far the highest concentration detected on site, with the next highest concentration of naphthalene recorded to be 279mg/kg in MG-CDW (TP117 at 4.2m) and 17.5m in MG-CW (TP126 at 0.5m). This occurrence of naphthalene at TP139 is considered

to be an isolated hotspot and not representative of wider contamination of the MG-CW material or site in general (see below for more detail).

- The current depth of the maximum naphthalene concentration in TP139 at 2.4m is below the level of perched water which would mean that the air filled porosity would fall to zero, resulting in a significant decrease in the modelled indoor air vapour concentration (circa 2 order of magnitude reduction). However, it should be noted that there is no groundwater data relating to locations in close vicinity to TP139 that can be used to compensate the model.
- Use of soil and groundwater concentrations is likely to significantly overestimate the source vapour concentration. However, as no vapour monitoring data is currently available, the soil and groundwater data have been used to provide conservative modelling results.
- The depth to contamination has been modelled as 0.60m as the remediation works will produce a development platform which leaves the site at least 600mm below finished level to accommodate the clean cover layer. This is therefore likely to be the minimum depth of contamination in the remediated site; subject to agreement with the regulators.
- Modelling has been undertaken assuming advective flow from the void through cracks in the slab and into the building. In reality, given the classification of the site as CS2, gas protection measures will be required which will include the installation of a gas protection membrane which, while not installed to mitigate vapour, will also significantly reduce vapour intrusion to the building. This has not been included in the modelling at this stage but can be incorporated into the model during any reassessment of vapour risk during the detailed design phase.

5.1.5 This detailed quantitative risk assessment has been undertaken on the basis that houses will be constructed with a minimum 150mm ventilated sub-floor void. If the foundation type varies from this assumption, the requirement for remediation or vapour protection measures will need to be reassessed to ensure that the assumptions used in the conceptual site model are appropriate to the alternative foundation type.

6 ADDITIONAL CONSIDERATIONS

6.1 Factors of Safety

6.1.1 In light of the aforementioned reasons, the undertaken modelling is considered to be suitably conservative. Consideration of additional factors of safety to be applied to the modelling are nonetheless also considered necessary.

6.1.2 No special preservation of soil samples was undertaken during the site works as recommended by BS10176: taking Soil Samples for the Determination of Volatile Organic Compounds (VOCs) Speciation. Data within the appendices of BS10176 indicates that the worst-case loss of volatiles (associated with the most volatile substances like benzene and toluene) can be up to an order of magnitude, though are found to be less for CoC with lower volatility.

6.1.3 Unknowns surrounding the construction of the floor slab, potential for blocking of void vents, robustness of data from the investigation and accounting for a membrane in the construction of the floor slabs also need to be considered. However, the undertaken modelling and assessments are considered to be suitably conservative in this respect due to the following considerations:

- Floor slab construction and potential risk of cracking larger than modelled will need to be considered at detailed design stage. Standard house types and data from the CLEA model have been used which are considered to be suitable at this stage.
- The air exchange rate in the void has been modelled as only one per day compared to a calculated 8 per day in accordance with ventilation calculations outlined within BS5925. Therefore, this is considered to account for potential blocked vents and other potential uncertainty in the initial modelling.
- The site investigation works are considered to be suitably robust to allow the design of the remediation works, which is what the current planning consent allows. While there were some limitations to the investigation due to restricted access and it is recognised that the nature of the site (i.e. historical landfill) is likely to be highly heterogeneous, potential shortcomings in the investigation will be mitigated as part of remediation considerations. It is understood that the upper 2 – 3 m of the site will be turned over as part of the proposed remedial works. This will afford close inspection and validation of the materials encountered, allowing areas of previously unknown contamination to be identified and also enabling

preparation of a detailed record of the remediation. This information will support any further DQRA required at detailed design stage (post remediation).

- As discussed above, the fact that a membrane has not been allowed for in the current model results in the model output being significantly more conservative than the scenario where a membrane is included in the floor slab. This can be picked up in any further DQRA undertaken at detailed design stage.

6.1.4 It is therefore considered appropriate to apply a factor of safety of 10 to the WMA modelling results to ensure that where contamination requires mitigation, it is identified and dealt with during the site works and this would be enforced through validation / verification procedures that are required to ensure that the remedial works are undertaken in accordance with the remediation strategy. When a factor of safety of 10 (i.e. one order of magnitude) is applied to the model results presented in Table 4.3, the concentration of naphthalene modelled in the MG-CW material is found to be unacceptable and requires mitigation.

6.2 Identified Naphthalene Hotspot

6.2.1 The exploratory hole log for TP139 indicates that the material at 2.4m associated with the recorded naphthalene concentration of 13,100mg/kg was recovered as wet material below the ingress of water at 2.2m. The log also indicates that the trial pit encountered a brick obstruction in the western face of the excavation and that it was located outside of the infilled brick pits (in the area of a former building associated with the brick works). The log and photographs from the trial pit indicate that the observed odour was only emanating from 2.2m (where the groundwater was encountered) and that it is possibly associated with the water ingress. However, it should be noted that no water samples are available from this trial pit or the immediate vicinity of this location).

6.2.2 Assessment of the PAH results for the samples recovered from the site using double ratio techniques (see plot with all results by soil type in Appendix E) indicates that this sample from TP139 is dissimilar to other samples. The double ratio PAH analysis indicates that it has a tyre oil signature which is different to the other MG-CW samples which generally exhibit a coal or coal tar signature consistent with suspected combustion products.

6.2.3 It is therefore considered that this maximum concentration of naphthalene recorded in the vicinity of the former brickworks building in TP139 is representative of a

localised hot spot (i.e. outlier). With the applied factor of safety, this is the only area which is found in this assessment to represent a potentially unacceptable risk to human health through vapours. This area should be carefully excavated during the remediation works with appropriate screening to allow impacted soils to be stockpiled separately and remediated. A provisional remediation target of 1,400mg/kg is considered appropriate for naphthalene in MG-CW (i.e. the modelled value summarised in Table 4 divided by the factor of safety of 10). This same method could also be used to derive remedial targets for other areas of previously unidentified contamination, if identified and / or required, during the remedial works.

7 SUMMARY

- 7.1.1 A remediation strategy should be developed to ensure that a robust system is in place for screening soils from the site. Validation testing together with record keeping will allow full characterisation of the post remediated site to be recorded. This will facilitate any DQRA requirements at post remediation - detailed design phase.
- 7.1.2 It is understood that independent of the potential risk to human health from vapours, as a minimum, gas protection measures in line with a CS2 classification will be required. While the assessments contained in this letter report indicate that vapours (with the exception of the naphthalene hotspot at TP1390) are considered unlikely to represent an unacceptable risk and that some source reduction would occur via remediation, there will still be a potential for low concentrations of hydrocarbon vapours at the site. Any membranes required to protect properties from ground gases should therefore also be designed to ensure that they will not be rendered ineffective by attack from vapour.
- 7.1.3 These assessments have been undertaken based on the current understanding of the CSM and with the data available at the time of reporting. This DQRA will also support the development of a remediation strategy to address the requirements of at tender stage (of the remediation and earthworks). Additional DQRA may be required during the detailed design stage and prior to development of the site in order to address the requirements of planning conditions associated with consent for remediation. This would be specifically associated with the separate planning application for development at the site.
- 7.1.4 The findings of the initial vapour DQRA and recommended remedial target for naphthalene in MG-CW will need to be agreed with appropriate regulators before being applied to the remediation of soils at the site.

APPENDICES

Appendix A
Indicative Made Ground Types Zoning Plan



DO NOT SCALE FROM THIS DRAWING

Legend

- Site Boundary
- Recorded Extent of Clay Pit Excavations
- Areas of Largely Suspected Combustion Waste
- Areas of Largely Suspected Construction & Demolition Waste
- Areas of Largely Suspected Combustion Waste >1m Thick
- Areas of Largely Suspected Colliery Spoil
- Areas of Suspected Household Waste
- Significant Areas of Largely Unknown Ground Conditions

Notes

Please refer to Drawing LD10385-003A for the exploratory hole legend. Areas outlined are indicative and are for illustrative purposes only. Only predominant Made Ground types are indicated. Vertical extent is not represented. Suspected household waste materials are centred on the areas in which they were encountered and are not indicative of the lateral and vertical extent. Actual ground conditions may vary between exploratory hole locations due to the inherent variability that would be expected within a historical landfill of this nature. BING imagery reproduced under license. Boundaries are indicative. Aerial imagery shown for context purposes only.

REVISION	DETAILS			DATE	DRN
		CHKD	APPD		
CLIENT					
NUVU DEVELOPMENTS LTD					
PROJECT					
TEN ACRES LANE					
DRAWING TITLE					
INDICATIVE MADE GROUND TYPES					
DRG No.			REV		
LD10385-021					
DRG SIZE		SCALE		DATE	
A3		1:2,750		29/08/22	
DRAWN BY		CHECKED BY		APPROVED BY	
JC		VC		AR	
 wardell armstrong ☐ LEEDS TEL 0113 831 5533 WWW.WARDELL-ARMSTRONG.COM ☐ BIRMINGHAM ☐ BOLTON ☐ CARLISLE ☐ EDINBURGH ☐ GLASGOW ☐ LONDON ☐ MANCHESTER ☐ NEWCASTLE UPON TYNE ☐ CARDIFF ☐ STOKE ON TRENT					

Appendix B
CLEA Model Reports

CLEA Software Version 1.071

Page 1 of 11

Report generated 21-Jul-22

Report title Vapour Only GAC, Part 1 - 1% SOM

Created by Rob Reuter at Wardell Armstrong



RESULTS



		Assessment Criterion (mg kg ⁻¹)			Ratio of ADE to HCV			Saturation Limit (mg kg ⁻¹)	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group					
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
1	Aliphatic EC >8-10 (S4UL)	NR	2.68E+01	2.68E+01	0.00	1.00	1.00	7.77E+01 (vap)	Yes	Yes	No	0	0	0	0	0	0
2	Aromatic EC >8-10 (S4UL)	NR	4.74E+01	4.74E+01	0.00	1.00	1.00	6.13E+02 (vap)	Yes	Yes	No	0	0	0	0	0	0
3	Aromatic EC >10-12 (S4UL)	NR	2.58E+02	2.58E+02	0.00	1.00	1.00	3.64E+02 (sol)	Yes	Yes	No	0	0	0	0	0	0
4	Aromatic EC >12-16 (S4UL)	NR	2.85E+03	2.85E+03	0.00	1.00	1.00	1.69E+02 (sol)	Yes	Yes	No	0	0	0	0	0	0
5	Aromatic EC >16-21 (S4UL)	5.09E+04	NR	NR	1.00	NR	NR	5.37E+01 (vap)	Yes	No	No	0	0	0	0	0	0
6	Aromatic EC >21-35 (S4UL)	4.94E+06	NR	NR	1.00	NR	NR	4.83E+00 (sol)	Yes	No	No	0	0	0	0	0	0
7	Naphthalene (S4UL)	NR	2.33E+00	NR	0.00	1.00	NR	7.64E+01 (sol)	No	No	No	0	0	0	0	0	0
8	Acenaphthylene (S4UL)	NR	4.66E+03	4.66E+03	0.00	1.00	1.00	8.61E+01 (sol)	No	No	No	0	0	0	0	0	0
9	Acenaphthene (S4UL)	NR	4.94E+03	4.94E+03	0.00	1.00	1.00	5.70E+01 (sol)	No	No	No	0	0	0	0	0	0
10	Fluorene (S4UL)	NR	6.22E+03	6.22E+03	0.00	1.00	1.00	3.09E+01 (sol)	No	No	No	0	0	0	0	0	0
11	Phenanthrene (S4UL)	NR	7.24E+03	7.24E+03	0.00	1.00	1.00	3.60E+01 (sol)	No	No	No	0	0	0	0	0	0
12	Fluoranthene (S4UL)	NR	4.03E+04	4.03E+04	0.00	1.00	1.00	1.89E+01 (vap)	No	No	No	0	0	0	0	0	0
13	Pyrene (S4UL)	NR	9.24E+04	9.24E+04	0.00	1.00	1.00	2.20E+00 (vap)	No	No	No	0	0	0	0	0	0
14	Benzo(a)anthracene (S4UL)	NR	3.39E+01	3.39E+01	0.00	1.00	1.00	1.71E+00 (sol)	No	No	No	0	0	0	0	0	0
15	Chrysene (S4UL)	NR	3.45E+02	3.45E+02	0.00	1.00	1.00	4.40E-01 (vap)	No	No	No	0	0	0	0	0	0
16	Benzo(b)fluoranthene (S4UL)	NR	1.22E+02	1.22E+02	0.00	1.00	1.00	1.22E+00 (sol)	No	No	No	0	0	0	0	0	0
17	Benzo(k)fluoranthene (S4UL)	NR	5.12E+03	NR	0.00	0.00	0.00	6.87E-01 (sol)	No	No	No	0	0	0	0	0	0
18	Benzo(a)pyrene (S4UL)	NR	1.33E+02	1.33E+02	0.00	1.00	1.00	9.11E-01 (vap)	No	No	No	0	0	0	0	0	0
19	Indeno(123-cd)pyrene (S4UL)	NR	1.16E+03	1.16E+03	0.00	1.00	1.00	6.13E-02 (vap)	No	No	No	0	0	0	0	0	0
20	Dibenzo(ah)anthracene (S4UL)	NR	7.11E+00	7.11E+00	0.00	1.00	1.00	3.93E-03 (vap)	No	No	No	0	0	0	0	0	0





Environment

Agency

		Assessment Criterion (mg kg ⁻¹)			Ratio of ADE to HCV			Saturation Limit (mg kg ⁻¹)	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group					
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
21	Benzene	NR	3.82E-01	NR	0.00	0.00	0.00	1.22E+03 (sol)	No	No	No	No	No	No	No	No	
22	Xylene, p-	NR	7.61E+01	7.61E+01	0.00	1.00	1.00	5.76E+02 (sol)	No	No	No	No	No	No	No	No	
23	Dibenzofuran	4.83E+01	NR	NR	1.00	NR	NR	1.45E+02 (vap)	No	No	No	0	0	0	0	0	
24	Carbazole	1.10E+01	NR	NR	1.00	NR	NR	2.25E-03 (vap)	No	No	No	0	0	0	0	0	
25	2-Methylnaphthalene	4.97E+01	NR	NR	1.00	NR	NR	3.24E+02 (sol)	No	No	No	0	0	0	0	0	
26	1,2,4-Trimethylbenzene	NR	5.83E-01	NR	NR	1.00	NR	5.57E+02 (vap)	No	Yes	No	0	0	0	0	0	
27	2,4-Dinitrotoluene	3.71E+03	NR	NR	1.00	NR	NR	1.41E+02 (sol)	No	No	No	0	0	0	0	0	
28	Chloromethane	NR	1.20E-02	NR	NR	1.00	NR	1.91E+03 (sol)	No	Yes	No	0	0	0	0	0	
29	Trichloroethene (S4UL)	NR	1.72E-02	1.72E-02	0.00	1.00	1.00	1.54E+03 (vap)	No	No	No	0	0	0	0	0	
30	2,4-Dimethylphenol	3.33E+02	NR	NR	1.00	NR	NR	1.38E+03 (vap)	No	No	No	0	0	0	0	0	



	Soil Distribution				Media Concentrations													
	Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
	%	%	%	%	mg kg ⁻¹	mg m ⁻³	mg kg ⁻¹	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW
1 Aliphatic EC >8-10 (S4UL)	96.1	0.1	3.8	100.0	2.68E+01	6.11E+03	NA	NA	NA	2.23E-01	1.97E-04	0.00E+00	NA	NA	NA	NA	NA	NA
2 Aromatic EC >8-10 (S4UL)	96.7	2.9	0.4	100.0	4.74E+01	1.26E+03	NA	NA	NA	4.62E-02	1.19E-04	0.00E+00	NA	NA	NA	NA	NA	NA
3 Aromatic EC >10-12 (S4UL)	98.1	1.8	0.1	100.0	2.58E+02	1.26E+03	NA	NA	NA	4.61E-02	2.78E-04	0.00E+00	NA	NA	NA	NA	NA	NA
4 Aromatic EC >12-16 (S4UL)	99.1	0.9	0.0	100.0	2.85E+03	1.23E+03	NA	NA	NA	4.61E-02	9.29E-04	0.00E+00	NA	NA	NA	NA	NA	NA
5 Aromatic EC >16-21 (S4UL)	99.7	0.3	0.0	100.0	5.09E+04	4.31E+02	NA	NA	NA	2.30E-02	3.02E-03	0.00E+00	NA	NA	NA	NA	NA	NA
6 Aromatic EC >21-35 (S4UL)	100.0	0.0	0.0	100.0	4.94E+06	1.68E+02	NA	NA	NA	2.01E-02	6.62E-02	0.00E+00	NA	NA	NA	NA	NA	NA
7 Naphthalene (S4UL)	93.2	6.8	0.0	100.0	2.33E+00	3.84E+00	NA	NA	NA	1.06E-03	1.21E-06	0.00E+00	NA	NA	NA	NA	NA	NA
8 Acenaphthylene (S4UL)	97.5	2.5	0.0	100.0	4.66E+03	2.45E+02	NA	NA	NA	9.23E-02	5.31E-04	0.00E+00	NA	NA	NA	NA	NA	NA
9 Acenaphthene (S4UL)	98.0	2.0	0.0	100.0	4.94E+03	2.70E+02	NA	NA	NA	9.23E-02	5.37E-04	0.00E+00	NA	NA	NA	NA	NA	NA
10 Fluorene (S4UL)	98.4	1.6	0.0	100.0	6.22E+03	1.54E+02	NA	NA	NA	6.15E-02	5.07E-04	0.00E+00	NA	NA	NA	NA	NA	NA
11 Phenanthrene (S4UL)	99.2	0.8	0.0	100.0	7.24E+03	3.22E+01	NA	NA	NA	1.92E-02	3.43E-04	0.00E+00	NA	NA	NA	NA	NA	NA
12 Fluoranthene (S4UL)	99.7	0.3	0.0	100.0	4.03E+04	2.40E+01	NA	NA	NA	1.92E-02	9.52E-04	0.00E+00	NA	NA	NA	NA	NA	NA
13 Pyrene (S4UL)	99.7	0.3	0.0	100.0	9.24E+04	5.52E+01	NA	NA	NA	4.61E-02	2.31E-03	0.00E+00	NA	NA	NA	NA	NA	NA
14 Benzo(a)anthracene (S4UL)	99.9	0.1	0.0	100.0	3.39E+01	2.38E-03	NA	NA	NA	2.29E-06	3.61E-07	0.00E+00	NA	NA	NA	NA	NA	NA
15 Chrysene (S4UL)	99.9	0.1	0.0	100.0	3.45E+02	3.44E-03	NA	NA	NA	4.43E-06	4.22E-06	0.00E+00	NA	NA	NA	NA	NA	NA
16 Benzo(b)fluoranthene (S4UL)	100.0	0.0	0.0	100.0	1.22E+02	4.11E-04	NA	NA	NA	5.37E-07	1.05E-06	0.00E+00	NA	NA	NA	NA	NA	NA
17 Benzo(k)fluoranthene (S4UL)	100.0	0.0	0.0	100.0	-3.36E-10	-6.80E-16	NA	NA	NA	-8.97E-19	-2.45E-18	0.00E+00	NA	NA	NA	NA	NA	NA
18 Benzo(a)pyrene (S4UL)	100.0	0.0	0.0	100.0	1.33E+02	3.14E-04	NA	NA	NA	4.14E-07	1.05E-06	0.00E+00	NA	NA	NA	NA	NA	NA
19 Indeno(123-cd)pyrene (S4UL)	99.9	0.1	0.0	100.0	1.16E+03	4.69E-03	NA	NA	NA	6.13E-06	1.08E-05	0.00E+00	NA	NA	NA	NA	NA	NA
20 Dibenzo(ah)anthracene (S4UL)	100.0	0.0	0.0	100.0	7.11E+00	3.56E-05	NA	NA	NA	4.41E-08	4.50E-08	0.00E+00	NA	NA	NA	NA	NA	NA



 Environment Agency		Soil Distribution				Media Concentrations													
		Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
	%	%	%	%	mg kg ⁻¹	mg m ⁻³	mg kg ⁻¹	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	
21	Benzene	57.3	39.9	2.8	100.0	-3.36E-10	-5.69E-08	NA	NA	NA	-1.89E-12	-1.99E-15	0.00E+00	NA	NA	NA	NA	NA	NA
22	Xylene, p-	89.9	9.5	0.6	100.0	7.61E+01	2.83E+03	NA	NA	NA	7.93E-02	1.90E-04	0.00E+00	NA	NA	NA	NA	NA	NA
23	Dibenzofuran	99.5	0.5	0.0	100.0	4.83E+01	7.88E+00	NA	NA	NA	1.54E-03	6.41E-06	0.00E+00	NA	NA	NA	NA	NA	NA
24	Carbazole	94.3	5.7	0.0	100.0	1.10E+01	2.64E+00	NA	NA	NA	7.70E-04	2.25E-06	0.00E+00	NA	NA	NA	NA	NA	NA
25	2-Methylnaphthalene	97.9	2.1	0.0	100.0	4.97E+01	2.33E+01	NA	NA	NA	6.06E-03	1.33E-05	0.00E+00	NA	NA	NA	NA	NA	NA
26	1,2,4-Trimethylbenzene	96.6	3.2	0.2	100.0	5.83E-01	5.89E+00	NA	NA	NA	1.54E-03	7.25E-07	0.00E+00	NA	NA	NA	NA	NA	NA
27	2,4-Dinitrotoluene	75.0	25.0	0.0	100.0	3.71E+03	1.25E+00	NA	NA	NA	3.04E-03	8.58E-04	0.00E+00	NA	NA	NA	NA	NA	NA
28	Chloromethane	11.2	76.3	12.5	100.0	1.20E-02	9.12E+00	NA	NA	NA	3.96E-03	1.82E-07	0.00E+00	NA	NA	NA	NA	NA	NA
29	Trichloroethene (S4UL)	73.0	24.3	2.8	100.0	1.72E-02	2.86E+00	NA	NA	NA	8.77E-04	9.59E-08	0.00E+00	NA	NA	NA	NA	NA	NA
30	2,4-Dimethylphenol	84.8	15.2	0.0	100.0	3.33E+02	6.61E+01	NA	NA	NA	3.08E-02	8.60E-05	0.00E+00	NA	NA	NA	NA	NA	NA

		Average Daily Exposure (mg kg ⁻¹ bw day ⁻¹)							Distribution by Pathway (%)							
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
1	Aliphatic EC >8-10 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.45E-01	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	50.00	0.00	0.00	50.00
2	Aromatic EC >8-10 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.99	0.01	0.00	50.00
3	Aromatic EC >10-12 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.99	0.01	0.00	50.00
4	Aromatic EC >12-16 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.95	0.05	0.00	50.00
5	Aromatic EC >16-21 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-02	5.62E+95	0.00E+00	0.00	0.00	0.00	0.00	49.70	0.30	50.00	0.00
6	Aromatic EC >21-35 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-02	5.62E+95	0.00E+00	0.00	0.00	0.00	0.00	43.47	6.53	50.00	0.00
7	Naphthalene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.90E-04	3.94E-04	1.70E-04	0.00	0.00	0.00	0.00	80.26	0.00	0.00	19.74
8	Acenaphthylene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-02	7.88E-06	6.67E-07	0.00	0.00	0.00	0.00	99.97	0.03	0.00	0.00
9	Acenaphthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-02	5.51E-05	1.52E-06	0.00	0.00	0.00	0.00	99.97	0.03	0.00	0.00
10	Fluorene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-02	3.32E-05	5.82E-06	0.00	0.00	0.00	0.00	99.95	0.04	0.00	0.01
11	Phenanthrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02	8.66E-05	3.14E-05	0.00	0.00	0.00	0.00	99.67	0.08	0.00	0.25
12	Fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02	1.97E-05	5.09E-06	0.00	0.00	0.00	0.00	99.73	0.23	0.00	0.04
13	Pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	1.97E-05	3.94E-06	0.00	0.00	0.00	0.00	99.76	0.23	0.00	0.01
14	Benzo(a)anthracene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-06	3.38E-06	6.67E-07	0.00	0.00	0.00	0.00	99.29	0.71	0.00	0.00
15	Chrysene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-06	6.19E-06	1.03E-06	0.00	0.00	0.00	0.00	95.84	4.16	0.00	0.00
16	Benzo(b)fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E-07	6.19E-06	7.88E-07	0.00	0.00	0.00	0.00	91.79	8.21	0.00	0.00
17	Benzo(k)fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-6.55E-19	5.06E-06	4.24E-07	0.00	0.00	0.00	0.00	44.48	5.52	0.00	0.00
18	Benzo(a)pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-07	6.19E-06	3.64E-07	0.00	0.00	0.00	0.00	89.66	10.34	0.00	0.00
19	Indeno(123-cd)pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.30E-06	5.63E-06	5.46E-07	0.00	0.00	0.00	0.00	92.56	7.44	0.00	0.00
20	Dibenzo(ah)anthracene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-08	2.25E-06	2.00E-06	0.00	0.00	0.00	0.00	95.57	4.43	0.00	0.00



		Average Daily Exposure (mg kg ⁻¹ bw day ⁻¹)							Distribution by Pathway (%)							
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
21	Benzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.23E-12	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00
22	Xylene, p-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.15E-02	6.19E-04	8.49E-03	0.00	0.00	0.00	0.00	85.85	0.01	0.00	14.14
23	Dibenzofuran	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.98	0.02	0.00	0.00
24	Carbazole	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.00E-04	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.99	0.01	0.00	0.00
25	2-Methylnaphthalene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.94E-03	0.00E+00	6.06E-05	0.00	0.00	0.00	0.00	98.47	0.01	0.00	1.52
26	1,2,4-Trimethylbenzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-03	1.35E-03	5.21E-03	0.00	0.00	0.00	0.00	50.00	0.00	10.29	39.71
27	2,4-Dinitrotoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	98.73	1.27	0.00	0.00
28	Chloromethane	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-03	0.00E+00	1.29E-02	0.00	0.00	0.00	0.00	50.00	0.00	0.00	50.00
29	Trichloroethene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.70E-04	5.63E-04	1.21E-02	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
30	2,4-Dimethylphenol	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-02	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.99	0.01	0.00	0.00



		Oral Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day ⁻¹)		Inhalation Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day ⁻¹)		Oral Mean Daily Intake ($\mu\text{g day}^{-1}$)		Inhalation Mean Daily Intake ($\mu\text{g day}^{-1}$)		Air-water partition coefficient (K_{ow}) ($\text{cm}^3 \text{cm}^{-3}$)		Coefficient of Diffusion in Air ($\text{m}^2 \text{s}^{-1}$)		Coefficient of Diffusion in Water ($\text{m}^2 \text{s}^{-1}$)		$\log K_{oc}$ ($\text{cm}^3 \text{g}^{-1}$)		$\log K_{ow}$ (dimensionless)		Dermal Absorption Fraction (dimensionless)		Soil-to-dust transport factor (g g^{-1} DW)		Sub-surface soil to indoor air correction factor (dimensionless)		Relative bioavailability via soil ingestion (unitless)		Relative bioavailability via dust inhalation (unitless)
1	Aliphatic EC >8-10 (S4UL)	TDI	100	TDI	290	9.99E+99		9.99E+99		4.15E+01		1.00E-05		1.00E-09		4.48		5.22		0.1		0.5		10		1		1
2	Aromatic EC >8-10 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		2.53E-01		1.00E-05		1.00E-09		3.2		3.69		0.1		0.5		10		1		1
3	Aromatic EC >10-12 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		7.22E-02		1.00E-05		1.00E-09		3.4		3.93		0.1		0.5		10		1		1
4	Aromatic EC >12-16 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		1.26E-02		1.00E-05		1.00E-09		3.7		4.29		0.1		0.5		10		1		1
5	Aromatic EC >16-21 (S4UL)	TDI	30	NR	0	9.99E+99		0		6.95E-04		1.00E-05		1.00E-09		4.15		4.82		0.1		0.5		10		1		1
6	Aromatic EC >21-35 (S4UL)	TDI	30	NR	0	9.99E+99		0		2.48E-05		1.00E-05		1.00E-09		5.1		5.95		0.1		0.5		10		1		1
7	Naphthalene (S4UL)	TDI	20	TDI	0.86	7		2.8		6.62E-03		6.52E-06		5.16E-10		2.81		3.34		0.13		0.5		1		1		1
8	Acenaphthylene (S4UL)	TDI	60	TDI	60	0.14		0.011		5.68E-04		5.97E-06		4.82E-10		3.26		3.91		0.13		0.5		1		1		1
9	Acenaphthene (S4UL)	TDI	60	TDI	60	0.98		0.025		7.59E-04		5.85E-06		4.70E-10		3.37		4.03		0.13		0.5		1		1		1
10	Fluorene (S4UL)	TDI	40	TDI	40	0.59		0.096		4.12E-04		5.58E-06		4.47E-10		3.45		4.13		0.13		0.5		1		1		1
11	Phenanthrene (S4UL)	TDI	12.5	TDI	12.5	1.54		0.518		1.43E-04		5.34E-06		4.32E-10		3.74		4.5		0.13		0.5		1		1		1
12	Fluoranthene (S4UL)	TDI	12.5	TDI	12.5	0.35		0.084		6.29E-05		5.01E-06		4.11E-10		4.26		5.13		0.13		0.5		1		1		1
13	Pyrene (S4UL)	TDI	30	TDI	30	0.35		0.065		5.64E-05		5.01E-06		4.15E-10		4.21		5.08		0.13		0.5		1		1		1
14	Benzo(a)anthracene (S4UL)	ID	0.155	ID	0.0015	0.06		0.011		3.16E-05		4.60E-06		3.80E-10		4.89		5.91		0.13		0.5		1		1		1
15	Chrysene (S4UL)	ID	0.31	ID	0.003	0.11		0.017		3.18E-06		4.57E-06		3.77E-10		4.74		5.73		0.13		0.5		1		1		1
16	Benzo(b)fluoranthene (S4UL)	ID	0.039	ID	0.00038	0.11		0.013		2.05E-06		4.36E-06		3.62E-10		5.02		6.08		0.13		0.5		1		1		1
17	Benzo(k)fluoranthene (S4UL)	ID	1.03	ID	0.01	0.09		0.007		1.74E-06		4.36E-06		3.62E-10		5.17		6.26		0.13		0.5		1		1		1
18	Benzo(a)pyrene (S4UL)	ID	0.031	ID	0.0003	0.11		0.006		1.76E-06		4.38E-06		3.67E-10		5.11		6.18		0.13		0.5		1		1		1
19	Indeno(123-cd)pyrene (S4UL)	ID	0.443	ID	0.0043	0.1		0.009		2.05E-06		4.17E-06		3.51E-10		4.94		5.97		0.13		0.5		1		1		1
20	Dibenzo(ah)anthracene (S4UL)	ID	0.0031	ID	0.00003	0.04		0.033		5.40E-06		4.08E-06		3.40E-10		5.27		6.38		0.13		0.5		1		1		1



		Oral Health Criteria Value ($\mu\text{g kg}^{-1} \text{ BW day}^{-1}$)	Inhalation Health Criteria Value ($\mu\text{g kg}^{-1} \text{ BW day}^{-1}$)	Oral Mean Daily Intake ($\mu\text{g day}^{-1}$)	Inhalation Mean Daily Intake ($\mu\text{g day}^{-1}$)	Air-water partition coefficient (K_{aw}) ($\text{cm}^3 \text{ cm}^{-3}$)	Coefficient of Diffusion in Air ($\text{m}^2 \text{ s}^{-1}$)	Coefficient of Diffusion in Water ($\text{m}^2 \text{ s}^{-1}$)	$\log K_{oc}$ ($\text{cm}^3 \text{ g}^{-1}$)	$\log K_{ow}$ (dimensionless)	Dermal Absorption Fraction (dimensionless)	Soil-to-dust transport factor ($\text{g g}^{-1} \text{ DW}$)	Sub-surface soil to indoor air correction factor (dimensionless)	Relative bioavailability via soil ingestion (unitless)	Relative bioavailability via dust inhalation (unitless)
21	Benzene	ID 0.29	ID 1.4	NR	NR	1.16E-01	8.77E-06	6.64E-10	1.83	2.13	0.1	0.5	10	1	1
22	Xylene, p-	TDI 180	TDI 60	11	140	1.07E-01	7.04E-06	5.31E-10	2.65	3.15	0.1	0.5	10	1	1
23	Dibenzofuran	TDI 1	NR 0	0	0	8.71E-03	4.10E-06	7.38E-10	3.962	4.12	0.03	0.5	1	1	1
24	Carbazole	ID 0.5	NR 0	NR	NR	1.15E-03	5.39E-06	4.40E-10	2.89	3.6	0.1	0.5	1	1	1
25	2-Methylnaphthalene	TDI 4	NR NR	0	1	6.06E-03	6.03E-06	4.75E-10	3.34	4	0.13	0.5	1	1	1
26	1,2,4-Trimethylbenzene	NR 0	TDI 2	24	86	8.56E-02	6.44E-06	4.87E-10	3.15	3.76	0.1	0.5	1	1	1
27	2,4-Dinitrotoluene	TDI 2	NR 0	0	0	3.67E-07	5.71E-06	4.66E-10	2.15	1.98	0.102	0.5	1	1	1
28	Chloromethane	NR 0	TDI 5.14	0	212	2.71E-01	1.28E-05	9.70E-10	0.84	0.91	0.1	0.5	1	1	1
29	Trichloroethene (S4UL)	ID 0.5	ID 0.57	10	200	1.87E-01	7.91E-06	6.23E-10	2.15	2.53	0.1	0.5	1	1	1
30	2,4-Dimethylphenol	TDI 20	NR 0	0	0	3.57E-04	6.56E-06	5.15E-10	2.42	2.35	0.1	0.5	1	1	1



		Soil-to-water partition coefficient (cm ³ g ⁻¹)	Vapour pressure (Pa)	Water solubility (mg L ⁻¹)	Soil-to-plant concentration factor for green vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for root vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tree fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)
1	Aliphatic EC >8-10 (S4UL)	1.75E+02	3.20E+02	4.27E-01	model	model	model	model	model	model
2	Aromatic EC >8-10 (S4UL)	9.19E+00	3.20E+02	6.46E+01	model	model	model	model	model	model
3	Aromatic EC >10-12 (S4UL)	1.46E+01	3.21E+01	2.45E+01	model	model	model	model	model	model
4	Aromatic EC >12-16 (S4UL)	2.91E+01	1.14E+00	5.75E+00	model	model	model	model	model	model
5	Aromatic EC >16-21 (S4UL)	8.19E+01	5.62E-03	6.53E-01	model	model	model	model	model	model
6	Aromatic EC >21-35 (S4UL)	7.30E+02	1.61E-06	6.61E-03	model	model	model	model	model	model
7	Naphthalene (S4UL)	3.74E+00	2.31E+00	1.90E+01	model	model	model	model	model	model
8	Acenaphthylene (S4UL)	1.06E+01	7.08E-02	7.95E+00	model	model	model	model	model	model
9	Acenaphthene (S4UL)	1.36E+01	7.37E-02	4.11E+00	model	model	model	model	model	model
10	Fluorene (S4UL)	1.63E+01	1.56E-02	1.86E+00	model	model	model	model	model	model
11	Phenanthrene (S4UL)	3.19E+01	2.82E-03	1.12E+00	model	model	model	model	model	model
12	Fluoranthene (S4UL)	1.06E+02	1.31E-04	2.30E-01	model	model	model	model	model	model
13	Pyrene (S4UL)	9.41E+01	1.53E-05	1.30E-01	model	model	model	model	model	model
14	Benzo(a)anthracene (S4UL)	4.50E+02	1.24E-06	3.80E-03	model	model	model	model	model	model
15	Chrysene (S4UL)	3.19E+02	4.52E-08	2.00E-03	model	model	model	model	model	model
16	Benzo(b)fluoranthene (S4UL)	6.07E+02	6.34E-08	2.00E-03	model	model	model	model	model	model
17	Benzo(k)fluoranthene (S4UL)	8.58E+02	1.64E-08	8.00E-04	model	model	model	model	model	model
18	Benzo(a)pyrene (S4UL)	7.47E+02	2.00E-08	3.80E-03	model	model	model	model	model	model
19	Indeno(123-cd)pyrene (S4UL)	5.05E+02	2.12E-09	2.00E-04	model	model	model	model	model	model
20	Dibenzo(ah)anthracene (S4UL)	1.08E+03	1.66E-10	6.00E-04	model	model	model	model	model	model



		Soil-to-water partition coefficient (cm ³ g ⁻¹)	Vapour pressure (Pa)	Water solubility (mg L ⁻¹)	Soil-to-plant concentration factor for green vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for root vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tree fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)
21	Benzene	3.92E-01	6.24E+03	1.78E+03	model	model	model	0.00E+00	0.00E+00	model
22	Xylene, p-	2.59E+00	4.75E+02	2.00E+02	model	model	model	0.00E+00	0.00E+00	model
23	Dibenzofuran	5.31E+01	3.31E-01	3.10E+00	model	model	model	model	model	model
24	Carbazole	4.50E+00	7.64E-06	1.16E+00	Model	Model	Model	Model	Model	Model
25	2-Methylnaphthalene	1.27E+01	3.41E+00	2.50E+01	model	model	model	model	model	model
26	1,2,4-Trimethylbenzene	8.19E+00	1.10E+02	5.59E+02	Model	Model	Model	Model	Model	Model
27	2,4-Dinitrotoluene	8.19E-01	1.54E-02	1.29E+02	Model	Model	Model	Model	Model	Model
28	Chloromethane	4.01E-02	3.31E+05	5.35E+03	Model	Model	Model	Model	Model	Model
29	Trichloroethene (S4UL)	8.19E-01	4.58E+03	1.37E+03	model	model	model	0.00E+00	0.00E+00	model
30	2,4-Dimethylphenol	1.53E+00	5.28E+00	8.11E+03	Model	Model	Model	Model	Model	Model

CLEA Software Version 1.071

Page 1 of 11

Report generated 08-Aug-22

Report title Vapour Only GAC, Part 2 - 1% SOM

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RESULTS

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CLEA Software Version 1.071

Page 1 of 11

Report generated

21-Jul-22

Report title

Vapour Only GAC, Part 1 - 2.3% SOM

Created by

Rob Reuter at Wardell Armstrong



Environment
Agency

RESULTS



		Assessment Criterion (mg kg ⁻¹)			Ratio of ADE to HCV			Saturation Limit (mg kg ⁻¹)	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group					
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
1	Aliphatic EC >8-10 (S4UL)	NR	6.04E+01	6.04E+01	0.00	1.00	1.00	1.75E+02 (vap)	Yes	Yes	No	0	0	0	0	0	0
2	Aromatic EC >8-10 (S4UL)	NR	1.07E+02	1.07E+02	0.00	1.00	1.00	1.38E+03 (vap)	Yes	Yes	No	0	0	0	0	0	0
3	Aromatic EC >10-12 (S4UL)	NR	5.88E+02	5.88E+02	0.00	1.00	1.00	8.28E+02 (sol)	Yes	Yes	No	0	0	0	0	0	0
4	Aromatic EC >12-16 (S4UL)	NR	6.53E+03	6.53E+03	0.00	1.00	1.00	3.86E+02 (sol)	Yes	Yes	No	0	0	0	0	0	0
5	Aromatic EC >16-21 (S4UL)	1.17E+05	NR	NR	1.00	NR	NR	1.23E+02 (vap)	Yes	No	No	0	0	0	0	0	0
6	Aromatic EC >21-35 (S4UL)	1.06E+07	NR	NR	1.00	NR	NR	1.11E+01 (sol)	Yes	No	No	0	0	0	0	0	0
7	Naphthalene (S4UL)	NR	5.16E+00	NR	0.00	1.00	NR	1.69E+02 (sol)	No	No	No	0	0	0	0	0	0
8	Acenaphthylene (S4UL)	NR	1.06E+04	1.06E+04	0.00	1.00	1.00	1.95E+02 (sol)	No	No	No	0	0	0	0	0	0
9	Acenaphthene (S4UL)	NR	1.12E+04	1.12E+04	0.00	1.00	1.00	1.30E+02 (sol)	No	No	No	0	0	0	0	0	0
10	Fluorene (S4UL)	NR	1.42E+04	1.42E+04	0.00	1.00	1.00	7.04E+01 (sol)	No	No	No	0	0	0	0	0	0
11	Phenanthrene (S4UL)	NR	1.66E+04	1.66E+04	0.00	1.00	1.00	8.24E+01 (sol)	No	No	No	0	0	0	0	0	0
12	Fluoranthene (S4UL)	NR	9.25E+04	9.25E+04	0.00	1.00	1.00	4.35E+01 (vap)	No	No	No	0	0	0	0	0	0
13	Pyrene (S4UL)	NR	2.12E+05	2.12E+05	0.00	1.00	1.00	5.05E+00 (vap)	No	No	No	0	0	0	0	0	0
14	Benzo(a)anthracene (S4UL)	NR	7.77E+01	7.77E+01	0.00	1.00	1.00	3.94E+00 (sol)	No	No	No	0	0	0	0	0	0
15	Chrysene (S4UL)	NR	7.77E+02	7.77E+02	0.00	1.00	1.00	1.01E+00 (vap)	No	No	No	0	0	0	0	0	0
16	Benzo(b)fluoranthene (S4UL)	NR	2.69E+02	2.69E+02	0.00	1.00	1.00	2.79E+00 (sol)	No	No	No	0	0	0	0	0	0
17	Benzo(k)fluoranthene (S4UL)	NR	1.11E+04	1.11E+04	0.00	1.00	1.00	1.58E+00 (sol)	No	No	No	0	0	0	0	0	0
18	Benzo(a)pyrene (S4UL)	NR	2.91E+02	2.91E+02	0.00	1.00	1.00	2.09E+00 (vap)	No	No	No	0	0	0	0	0	0
19	Indeno(123-cd)pyrene (S4UL)	NR	2.56E+03	2.56E+03	0.00	1.00	1.00	1.41E-01 (vap)	No	No	No	0	0	0	0	0	0
20	Dibenzo(ah)anthracene (S4UL)	NR	1.60E+01	1.60E+01	0.00	1.00	1.00	9.03E-03 (vap)	No	No	No	0	0	0	0	0	0





Environment

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		Assessment Criterion (mg kg ⁻¹)			Ratio of ADE to HCV			Saturation Limit (mg kg ⁻¹)	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group						
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit	
21	Benzene	NR	6.67E-01	6.67E-01	0.00	1.00	1.00	2.12E+03 (sol)	No	No	No	No	No	No	No	No		
22	Xylene, p-	NR	1.65E+02	1.65E+02	0.00	1.00	1.00	1.25E+03 (sol)	No	No	No	No	No	No	No	No		
23	Dibenzofuran	1.11E+02	NR	NR	1.00	NR	NR	3.32E+02 (vap)	No	No	No	0	0	0	0	0		
24	Carbazole	2.44E+01	NR	NR	1.00	NR	NR	5.02E-03 (vap)	No	No	No	0	0	0	0	0		
25	2-Methylnaphthalene	1.13E+02	NR	NR	1.00	NR	NR	7.36E+02 (sol)	No	No	No	0	0	0	0	0		
26	1,2,4-Trimethylbenzene	NR	1.32E+00	NR	NR	1.00	NR	1.26E+03 (vap)	No	Yes	No	0	0	0	0	0		
27	2,4-Dinitrotoluene	7.28E+03	NR	NR	1.00	NR	NR	2.78E+02 (sol)	No	No	No	0	0	0	0	0		
28	Chloromethane	NR	1.38E-02	NR	NR	1.00	NR	2.19E+03 (sol)	No	Yes	No	0	0	0	0	0		
29	Trichloroethene (S4UL)	NR	3.34E-02	3.34E-02	0.00	1.00	1.00	2.99E+03 (vap)	No	No	No	0	0	0	0	0		
30	2,4-Dimethylphenol	7.00E+02	NR	NR	1.00	NR	NR	2.90E+03 (vap)	No	No	No	0	0	0	0	0		



	Soil Distribution				Media Concentrations													
	Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
	%	%	%	%	mg kg ⁻¹	mg m ⁻³	mg kg ⁻¹	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW
1 Aliphatic EC >8-10 (S4UL)	98.3	0.1	1.7	100.0	6.04E+01	6.11E+03	NA	NA	NA	2.23E-01	2.95E-04	0.00E+00	NA	NA	NA	NA	NA	NA
2 Aromatic EC >8-10 (S4UL)	98.5	1.3	0.2	100.0	1.07E+02	1.26E+03	NA	NA	NA	4.62E-02	1.79E-04	0.00E+00	NA	NA	NA	NA	NA	NA
3 Aromatic EC >10-12 (S4UL)	99.2	0.8	0.0	100.0	5.88E+02	1.26E+03	NA	NA	NA	4.62E-02	4.20E-04	0.00E+00	NA	NA	NA	NA	NA	NA
4 Aromatic EC >12-16 (S4UL)	99.6	0.4	0.0	100.0	6.53E+03	1.23E+03	NA	NA	NA	4.61E-02	1.41E-03	0.00E+00	NA	NA	NA	NA	NA	NA
5 Aromatic EC >16-21 (S4UL)	99.9	0.1	0.0	100.0	1.17E+05	4.29E+02	NA	NA	NA	2.29E-02	4.57E-03	0.00E+00	NA	NA	NA	NA	NA	NA
6 Aromatic EC >21-35 (S4UL)	100.0	0.0	0.0	100.0	1.06E+07	1.57E+02	NA	NA	NA	1.88E-02	9.41E-02	0.00E+00	NA	NA	NA	NA	NA	NA
7 Naphthalene (S4UL)	96.9	3.1	0.0	100.0	5.16E+00	3.84E+00	NA	NA	NA	1.06E-03	1.80E-06	0.00E+00	NA	NA	NA	NA	NA	NA
8 Acenaphthylene (S4UL)	98.9	1.1	0.0	100.0	1.06E+04	2.45E+02	NA	NA	NA	9.23E-02	8.00E-04	0.00E+00	NA	NA	NA	NA	NA	NA
9 Acenaphthene (S4UL)	99.1	0.9	0.0	100.0	1.12E+04	2.70E+02	NA	NA	NA	9.23E-02	8.10E-04	0.00E+00	NA	NA	NA	NA	NA	NA
10 Fluorene (S4UL)	99.3	0.7	0.0	100.0	1.42E+04	1.54E+02	NA	NA	NA	6.15E-02	7.65E-04	0.00E+00	NA	NA	NA	NA	NA	NA
11 Phenanthrene (S4UL)	99.6	0.4	0.0	100.0	1.66E+04	3.22E+01	NA	NA	NA	1.92E-02	5.19E-04	0.00E+00	NA	NA	NA	NA	NA	NA
12 Fluoranthene (S4UL)	99.9	0.1	0.0	100.0	9.25E+04	2.39E+01	NA	NA	NA	1.92E-02	1.44E-03	0.00E+00	NA	NA	NA	NA	NA	NA
13 Pyrene (S4UL)	99.9	0.1	0.0	100.0	2.12E+05	5.52E+01	NA	NA	NA	4.60E-02	3.49E-03	0.00E+00	NA	NA	NA	NA	NA	NA
14 Benzo(a)anthracene (S4UL)	100.0	0.0	0.0	100.0	7.77E+01	2.37E-03	NA	NA	NA	2.28E-06	5.46E-07	0.00E+00	NA	NA	NA	NA	NA	NA
15 Chrysene (S4UL)	100.0	0.0	0.0	100.0	7.77E+02	3.37E-03	NA	NA	NA	4.33E-06	6.26E-06	0.00E+00	NA	NA	NA	NA	NA	NA
16 Benzo(b)fluoranthene (S4UL)	100.0	0.0	0.0	100.0	2.69E+02	3.94E-04	NA	NA	NA	5.15E-07	1.53E-06	0.00E+00	NA	NA	NA	NA	NA	NA
17 Benzo(k)fluoranthene (S4UL)	100.0	0.0	0.0	100.0	1.11E+04	9.82E-03	NA	NA	NA	1.30E-05	5.36E-05	0.00E+00	NA	NA	NA	NA	NA	NA
18 Benzo(a)pyrene (S4UL)	100.0	0.0	0.0	100.0	2.91E+02	2.98E-04	NA	NA	NA	3.93E-07	1.51E-06	0.00E+00	NA	NA	NA	NA	NA	NA
19 Indeno(123-cd)pyrene (S4UL)	100.0	0.0	0.0	100.0	2.56E+03	4.52E-03	NA	NA	NA	5.90E-06	1.58E-05	0.00E+00	NA	NA	NA	NA	NA	NA
20 Dibenzo(ah)anthracene (S4UL)	100.0	0.0	0.0	100.0	1.60E+01	3.48E-05	NA	NA	NA	4.31E-08	6.67E-08	0.00E+00	NA	NA	NA	NA	NA	NA



 Environment Agency		Soil Distribution				Media Concentrations													
		Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
	%	%	%	%	mg kg ⁻¹	mg m ⁻³	mg kg ⁻¹	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	
21	Benzene	75.5	22.8	1.6	100.0	6.67E-01	6.48E+01	NA	NA	NA	2.15E-03	3.00E-06	0.00E+00	NA	NA	NA	NA	NA	NA
22	Xylene, p-	95.4	4.4	0.3	100.0	1.65E+02	2.83E+03	NA	NA	NA	7.93E-02	2.79E-04	0.00E+00	NA	NA	NA	NA	NA	NA
23	Dibenzofuran	99.8	0.2	0.0	100.0	1.11E+02	7.88E+00	NA	NA	NA	1.54E-03	9.70E-06	0.00E+00	NA	NA	NA	NA	NA	NA
24	Carbazole	97.4	2.6	0.0	100.0	2.44E+01	2.64E+00	NA	NA	NA	7.69E-04	3.36E-06	0.00E+00	NA	NA	NA	NA	NA	NA
25	2-Methylnaphthalene	99.1	0.9	0.0	100.0	1.13E+02	2.33E+01	NA	NA	NA	6.06E-03	2.00E-05	0.00E+00	NA	NA	NA	NA	NA	NA
26	1,2,4-Trimethylbenzene	98.5	1.4	0.1	100.0	1.32E+00	5.88E+00	NA	NA	NA	1.54E-03	1.09E-06	0.00E+00	NA	NA	NA	NA	NA	NA
27	2,4-Dinitrotoluene	87.4	12.6	0.0	100.0	7.28E+03	1.24E+00	NA	NA	NA	3.02E-03	1.20E-03	0.00E+00	NA	NA	NA	NA	NA	NA
28	Chloromethane	22.5	66.6	10.9	100.0	1.38E-02	9.12E+00	NA	NA	NA	3.96E-03	1.95E-07	0.00E+00	NA	NA	NA	NA	NA	NA
29	Trichloroethene (S4UL)	86.1	12.5	1.4	100.0	3.34E-02	2.86E+00	NA	NA	NA	8.77E-04	1.34E-07	0.00E+00	NA	NA	NA	NA	NA	NA
30	2,4-Dimethylphenol	92.8	7.2	0.0	100.0	7.00E+02	6.61E+01	NA	NA	NA	3.08E-02	1.25E-04	0.00E+00	NA	NA	NA	NA	NA	NA

		Average Daily Exposure (mg kg ⁻¹ bw day ⁻¹)						Distribution by Pathway (%)								
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
1	Aliphatic EC >8-10 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.45E-01	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	50.00	0.00	0.00	50.00
2	Aromatic EC >8-10 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.99	0.01	0.00	50.00
3	Aromatic EC >10-12 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.98	0.02	0.00	50.00
4	Aromatic EC >12-16 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.93	0.07	0.00	50.00
5	Aromatic EC >16-21 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-02	5.62E+95	0.00E+00	0.00	0.00	0.00	0.00	49.55	0.45	50.00	0.00
6	Aromatic EC >21-35 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-02	5.62E+95	0.00E+00	0.00	0.00	0.00	0.00	40.72	9.28	50.00	0.00
7	Naphthalene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.90E-04	3.94E-04	1.70E-04	0.00	0.00	0.00	0.00	80.26	0.01	0.00	19.74
8	Acenaphthylene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-02	7.88E-06	6.67E-07	0.00	0.00	0.00	0.00	99.96	0.04	0.00	0.00
9	Acenaphthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-02	5.51E-05	1.52E-06	0.00	0.00	0.00	0.00	99.96	0.04	0.00	0.00
10	Fluorene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-02	3.32E-05	5.82E-06	0.00	0.00	0.00	0.00	99.93	0.06	0.00	0.01
11	Phenanthrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02	8.66E-05	3.14E-05	0.00	0.00	0.00	0.00	99.63	0.12	0.00	0.25
12	Fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02	1.97E-05	5.09E-06	0.00	0.00	0.00	0.00	99.62	0.34	0.00	0.04
13	Pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	1.97E-05	3.94E-06	0.00	0.00	0.00	0.00	99.64	0.34	0.00	0.01
14	Benzo(a)anthracene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-06	3.38E-06	6.67E-07	0.00	0.00	0.00	0.00	98.92	1.08	0.00	0.00
15	Chrysene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-06	6.19E-06	1.03E-06	0.00	0.00	0.00	0.00	93.82	6.18	0.00	0.00
16	Benzo(b)fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E-07	6.19E-06	7.88E-07	0.00	0.00	0.00	0.00	88.05	11.95	0.00	0.00
17	Benzo(k)fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-05	5.06E-06	4.24E-07	0.00	0.00	0.00	0.00	84.16	15.84	0.00	0.00
18	Benzo(a)pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-07	6.19E-06	3.64E-07	0.00	0.00	0.00	0.00	85.11	14.89	0.00	0.00
19	Indeno(123-cd)pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.30E-06	5.63E-06	5.46E-07	0.00	0.00	0.00	0.00	89.13	10.87	0.00	0.00
20	Dibenzo(ah)anthracene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-08	2.25E-06	2.00E-06	0.00	0.00	0.00	0.00	93.43	6.57	0.00	0.00



		Average Daily Exposure (mg kg ⁻¹ bw day ⁻¹)							Distribution by Pathway (%)							
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
21	Benzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.99	0.01	0.00	0.00
22	Xylene, p-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.15E-02	6.19E-04	8.49E-03	0.00	0.00	0.00	0.00	85.84	0.01	0.00	14.14
23	Dibenzofuran	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.97	0.03	0.00	0.00
24	Carbazole	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.00E-04	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.98	0.02	0.00	0.00
25	2-Methylnaphthalene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.94E-03	0.00E+00	6.06E-05	0.00	0.00	0.00	0.00	98.47	0.01	0.00	1.52
26	1,2,4-Trimethylbenzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-03	1.35E-03	5.21E-03	0.00	0.00	0.00	0.00	50.00	0.00	10.29	39.71
27	2,4-Dinitrotoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	98.23	1.77	0.00	0.00
28	Chloromethane	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-03	0.00E+00	1.29E-02	0.00	0.00	0.00	0.00	50.00	0.00	0.00	50.00
29	Trichloroethene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.70E-04	5.63E-04	1.21E-02	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
30	2,4-Dimethylphenol	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-02	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.98	0.02	0.00	0.00



		Oral Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day ⁻¹)		Inhalation Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day ⁻¹)		Oral Mean Daily Intake ($\mu\text{g day}^{-1}$)		Inhalation Mean Daily Intake ($\mu\text{g day}^{-1}$)		Air-water partition coefficient (K_{ow}) ($\text{cm}^3 \text{cm}^{-3}$)		Coefficient of Diffusion in Air ($\text{m}^2 \text{s}^{-1}$)		Coefficient of Diffusion in Water ($\text{m}^2 \text{s}^{-1}$)		$\log K_{oc}$ ($\text{cm}^3 \text{g}^{-1}$)		$\log K_{ow}$ (dimensionless)		Dermal Absorption Fraction (dimensionless)		Soil-to-dust transport factor (g g^{-1} DW)		Sub-surface soil to indoor air correction factor (dimensionless)		Relative bioavailability via soil ingestion (unitless)		Relative bioavailability via dust inhalation (unitless)
1	Aliphatic EC >8-10 (S4UL)	TDI	100	TDI	290	9.99E+99		9.99E+99		4.15E+01		1.00E-05		1.00E-09		4.48		5.22		0.1		0.5		10		1		1
2	Aromatic EC >8-10 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		2.53E-01		1.00E-05		1.00E-09		3.2		3.69		0.1		0.5		10		1		1
3	Aromatic EC >10-12 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		7.22E-02		1.00E-05		1.00E-09		3.4		3.93		0.1		0.5		10		1		1
4	Aromatic EC >12-16 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		1.26E-02		1.00E-05		1.00E-09		3.7		4.29		0.1		0.5		10		1		1
5	Aromatic EC >16-21 (S4UL)	TDI	30	NR	0	9.99E+99		0		6.95E-04		1.00E-05		1.00E-09		4.15		4.82		0.1		0.5		10		1		1
6	Aromatic EC >21-35 (S4UL)	TDI	30	NR	0	9.99E+99		0		2.48E-05		1.00E-05		1.00E-09		5.1		5.95		0.1		0.5		10		1		1
7	Naphthalene (S4UL)	TDI	20	TDI	0.86	7		2.8		6.62E-03		6.52E-06		5.16E-10		2.81		3.34		0.13		0.5		1		1		1
8	Acenaphthylene (S4UL)	TDI	60	TDI	60	0.14		0.011		5.68E-04		5.97E-06		4.82E-10		3.26		3.91		0.13		0.5		1		1		1
9	Acenaphthene (S4UL)	TDI	60	TDI	60	0.98		0.025		7.59E-04		5.85E-06		4.70E-10		3.37		4.03		0.13		0.5		1		1		1
10	Fluorene (S4UL)	TDI	40	TDI	40	0.59		0.096		4.12E-04		5.58E-06		4.47E-10		3.45		4.13		0.13		0.5		1		1		1
11	Phenanthrene (S4UL)	TDI	12.5	TDI	12.5	1.54		0.518		1.43E-04		5.34E-06		4.32E-10		3.74		4.5		0.13		0.5		1		1		1
12	Fluoranthene (S4UL)	TDI	12.5	TDI	12.5	0.35		0.084		6.29E-05		5.01E-06		4.11E-10		4.26		5.13		0.13		0.5		1		1		1
13	Pyrene (S4UL)	TDI	30	TDI	30	0.35		0.065		5.64E-05		5.01E-06		4.15E-10		4.21		5.08		0.13		0.5		1		1		1
14	Benzo(a)anthracene (S4UL)	ID	0.155	ID	0.0015	0.06		0.011		3.16E-05		4.60E-06		3.80E-10		4.89		5.91		0.13		0.5		1		1		1
15	Chrysene (S4UL)	ID	0.31	ID	0.003	0.11		0.017		3.18E-06		4.57E-06		3.77E-10		4.74		5.73		0.13		0.5		1		1		1
16	Benzo(b)fluoranthene (S4UL)	ID	0.039	ID	0.00038	0.11		0.013		2.05E-06		4.36E-06		3.62E-10		5.02		6.08		0.13		0.5		1		1		1
17	Benzo(k)fluoranthene (S4UL)	ID	1.03	ID	0.01	0.09		0.007		1.74E-06		4.36E-06		3.62E-10		5.17		6.26		0.13		0.5		1		1		1
18	Benzo(a)pyrene (S4UL)	ID	0.031	ID	0.0003	0.11		0.006		1.76E-06		4.38E-06		3.67E-10		5.11		6.18		0.13		0.5		1		1		1
19	Indeno(123-cd)pyrene (S4UL)	ID	0.443	ID	0.0043	0.1		0.009		2.05E-06		4.17E-06		3.51E-10		4.94		5.97		0.13		0.5		1		1		1
20	Dibenzo(ah)anthracene (S4UL)	ID	0.0031	ID	0.00003	0.04		0.033		5.40E-06		4.08E-06		3.40E-10		5.27		6.38		0.13		0.5		1		1		1



		Oral Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day^{-1})		Inhalation Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day^{-1})		Oral Mean Daily Intake ($\mu\text{g day}^{-1}$)		Inhalation Mean Daily Intake ($\mu\text{g day}^{-1}$)		Air-water partition coefficient (K_{aw}) ($\text{cm}^3 \text{cm}^{-3}$)		Coefficient of Diffusion in Air ($\text{m}^2 \text{s}^{-1}$)		Coefficient of Diffusion in Water ($\text{m}^2 \text{s}^{-1}$)		$\log K_{oc}$ ($\text{cm}^3 \text{g}^{-1}$)		$\log K_{ow}$ (dimensionless)		Dermal Absorption Fraction (dimensionless)		Soil-to-dust transport factor (g g^{-1} DW)		Sub-surface soil to indoor air correction factor (dimensionless)		Relative bioavailability via soil ingestion (unitless)		Relative bioavailability via dust inhalation (unitless)
21	Benzene	ID	0.29	ID	1.4	NR		NR		1.16E-01		8.77E-06		6.64E-10		1.83		2.13		0.1		0.5		10		1		1
22	Xylene, p-	TDI	180	TDI	60	11		140		1.07E-01		7.04E-06		5.31E-10		2.65		3.15		0.1		0.5		10		1		1
23	Dibenzofuran	TDI	1	NR	0	0		0		8.71E-03		4.10E-06		7.38E-10		3.962		4.12		0.03		0.5		1		1		1
24	Carbazole	ID	0.5	NR	0	NR		NR		1.15E-03		5.39E-06		4.40E-10		2.89		3.6		0.1		0.5		1		1		1
25	2-Methylnaphthalene	TDI	4	NR	NR	0		1		6.06E-03		6.03E-06		4.75E-10		3.34		4		0.13		0.5		1		1		1
26	1,2,4-Trimethylbenzene	NR	0	TDI	2	24		86		8.56E-02		6.44E-06		4.87E-10		3.15		3.76		0.1		0.5		1		1		1
27	2,4-Dinitrotoluene	TDI	2	NR	0	0		0		3.67E-07		5.71E-06		4.66E-10		2.15		1.98		0.102		0.5		1		1		1
28	Chloromethane	NR	0	TDI	5.14	0		212		2.71E-01		1.28E-05		9.70E-10		0.84		0.91		0.1		0.5		1		1		1
29	Trichloroethene (S4UL)	ID	0.5	ID	0.57	10		200		1.87E-01		7.91E-06		6.23E-10		2.15		2.53		0.1		0.5		1		1		1
30	2,4-Dimethylphenol	TDI	20	NR	0	0		0		3.57E-04		6.56E-06		5.15E-10		2.42		2.35		0.1		0.5		1		1		1



		Soil-to-water partition coefficient (cm ³ g ⁻¹)	Vapour pressure (Pa)	Water solubility (mg L ⁻¹)	Soil-to-plant concentration factor for green vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for root vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tree fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)
1	Aliphatic EC >8-10 (S4UL)	4.03E+02	3.20E+02	4.27E-01	model	model	model	model	model	model
2	Aromatic EC >8-10 (S4UL)	2.11E+01	3.20E+02	6.46E+01	model	model	model	model	model	model
3	Aromatic EC >10-12 (S4UL)	3.35E+01	3.21E+01	2.45E+01	model	model	model	model	model	model
4	Aromatic EC >12-16 (S4UL)	6.69E+01	1.14E+00	5.75E+00	model	model	model	model	model	model
5	Aromatic EC >16-21 (S4UL)	1.88E+02	5.62E-03	6.53E-01	model	model	model	model	model	model
6	Aromatic EC >21-35 (S4UL)	1.68E+03	1.61E-06	6.61E-03	model	model	model	model	model	model
7	Naphthalene (S4UL)	8.61E+00	2.31E+00	1.90E+01	model	model	model	model	model	model
8	Acenaphthylene (S4UL)	2.43E+01	7.08E-02	7.95E+00	model	model	model	model	model	model
9	Acenaphthene (S4UL)	3.13E+01	7.37E-02	4.11E+00	model	model	model	model	model	model
10	Fluorene (S4UL)	3.76E+01	1.56E-02	1.86E+00	model	model	model	model	model	model
11	Phenanthrene (S4UL)	7.33E+01	2.82E-03	1.12E+00	model	model	model	model	model	model
12	Fluoranthene (S4UL)	2.43E+02	1.31E-04	2.30E-01	model	model	model	model	model	model
13	Pyrene (S4UL)	2.16E+02	1.53E-05	1.30E-01	model	model	model	model	model	model
14	Benzo(a)anthracene (S4UL)	1.04E+03	1.24E-06	3.80E-03	model	model	model	model	model	model
15	Chrysene (S4UL)	7.33E+02	4.52E-08	2.00E-03	model	model	model	model	model	model
16	Benzo(b)fluoranthene (S4UL)	1.40E+03	6.34E-08	2.00E-03	model	model	model	model	model	model
17	Benzo(k)fluoranthene (S4UL)	1.97E+03	1.64E-08	8.00E-04	model	model	model	model	model	model
18	Benzo(a)pyrene (S4UL)	1.72E+03	2.00E-08	3.80E-03	model	model	model	model	model	model
19	Indeno(123-cd)pyrene (S4UL)	1.16E+03	2.12E-09	2.00E-04	model	model	model	model	model	model
20	Dibenzo(ah)anthracene (S4UL)	2.48E+03	1.66E-10	6.00E-04	model	model	model	model	model	model



		Soil-to-water partition coefficient (cm ³ g ⁻¹)	Vapour pressure (Pa)	Water solubility (mg L ⁻¹)	Soil-to-plant concentration factor for green vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for root vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tree fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)
21	Benzene	9.02E-01	6.24E+03	1.78E+03	model	model	model	0.00E+00	0.00E+00	model
22	Xylene, p-	5.96E+00	4.75E+02	2.00E+02	model	model	model	0.00E+00	0.00E+00	model
23	Dibenzofuran	1.22E+02	3.31E-01	3.10E+00	model	model	model	model	model	model
24	Carbazole	1.04E+01	7.64E-06	1.16E+00	Model	Model	Model	Model	Model	Model
25	2-Methylnaphthalene	2.92E+01	3.41E+00	2.50E+01	model	model	model	model	model	model
26	1,2,4-Trimethylbenzene	1.88E+01	1.10E+02	5.59E+02	Model	Model	Model	Model	Model	Model
27	2,4-Dinitrotoluene	1.88E+00	1.54E-02	1.29E+02	Model	Model	Model	Model	Model	Model
28	Chloromethane	9.23E-02	3.31E+05	5.35E+03	Model	Model	Model	Model	Model	Model
29	Trichloroethene (S4UL)	1.88E+00	4.58E+03	1.37E+03	model	model	model	0.00E+00	0.00E+00	model
30	2,4-Dimethylphenol	3.51E+00	5.28E+00	8.11E+03	Model	Model	Model	Model	Model	Model

CLEA Software Version 1.071

Page 1 of 11

Report generated 08-Aug-22

Report title Vapour Only GAC, Part 2 - 2.3% SOM

Created by Rob Reuter at Wardell Armstrong



RESULTS

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CLEA Software Version 1.071

Page 1 of 11

Report generated

21-Jul-22

Report title

Vapour Only GAC, Part 1 - 5% SOM

Created by

Rob Reuter at Wardell Armstrong



RESULTS



		Assessment Criterion (mg kg ⁻¹)			Ratio of ADE to HCV			Saturation Limit (mg kg ⁻¹)	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group					
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
1	Aliphatic EC >8-10 (S4UL)	NR	1.30E+02	1.30E+02	0.00	1.00	1.00	3.76E+02 (vap)	Yes	Yes	No	0	0	0	0	0	0
2	Aromatic EC >8-10 (S4UL)	NR	2.31E+02	2.31E+02	0.00	1.00	1.00	2.99E+03 (vap)	Yes	Yes	No	0	0	0	0	0	0
3	Aromatic EC >10-12 (S4UL)	NR	1.27E+03	1.27E+03	0.00	1.00	1.00	1.79E+03 (sol)	Yes	Yes	No	0	0	0	0	0	0
4	Aromatic EC >12-16 (S4UL)	NR	1.42E+04	1.42E+04	0.00	1.00	1.00	8.37E+02 (sol)	Yes	Yes	No	0	0	0	0	0	0
5	Aromatic EC >16-21 (S4UL)	2.52E+05	NR	NR	1.00	NR	NR	2.68E+02 (vap)	Yes	No	No	0	0	0	0	0	0
6	Aromatic EC >21-35 (S4UL)	2.13E+07	NR	NR	1.00	NR	NR	2.41E+01 (sol)	Yes	No	No	0	0	0	0	0	0
7	Naphthalene (S4UL)	NR	1.10E+01	NR	0.00	1.00	NR	3.61E+02 (sol)	No	No	No	0	0	0	0	0	0
8	Acenaphthylene (S4UL)	NR	2.28E+04	2.28E+04	0.00	1.00	1.00	4.22E+02 (sol)	No	No	No	0	0	0	0	0	0
9	Acenaphthene (S4UL)	NR	2.43E+04	2.43E+04	0.00	1.00	1.00	2.81E+02 (sol)	No	No	No	0	0	0	0	0	0
10	Fluorene (S4UL)	NR	3.07E+04	3.07E+04	0.00	1.00	1.00	1.53E+02 (sol)	No	No	No	0	0	0	0	0	0
11	Phenanthrene (S4UL)	NR	3.59E+04	3.59E+04	0.00	1.00	1.00	1.79E+02 (sol)	No	No	No	0	0	0	0	0	0
12	Fluoranthene (S4UL)	NR	2.01E+05	2.01E+05	0.00	1.00	1.00	9.45E+01 (vap)	No	No	No	0	0	0	0	0	0
13	Pyrene (S4UL)	NR	4.60E+05	4.60E+05	0.00	1.00	1.00	1.10E+01 (vap)	No	No	No	0	0	0	0	0	0
14	Benzo(a)anthracene (S4UL)	NR	1.68E+02	1.68E+02	0.00	1.00	1.00	8.56E+00 (sol)	No	No	No	0	0	0	0	0	0
15	Chrysene (S4UL)	NR	1.64E+03	1.64E+03	0.00	1.00	1.00	2.20E+00 (vap)	No	No	No	0	0	0	0	0	0
16	Benzo(b)fluoranthene (S4UL)	NR	5.52E+02	5.52E+02	0.00	1.00	1.00	6.07E+00 (sol)	No	No	No	0	0	0	0	0	0
17	Benzo(k)fluoranthene (S4UL)	NR	2.25E+04	2.25E+04	0.00	1.00	1.00	3.43E+00 (sol)	No	No	No	0	0	0	0	0	0
18	Benzo(a)pyrene (S4UL)	NR	5.91E+02	5.91E+02	0.00	1.00	1.00	4.55E+00 (vap)	No	No	No	0	0	0	0	0	0
19	Indeno(123-cd)pyrene (S4UL)	NR	5.29E+03	5.29E+03	0.00	1.00	1.00	3.06E-01 (vap)	No	No	No	0	0	0	0	0	0
20	Dibenzo(ah)anthracene (S4UL)	NR	3.37E+01	3.37E+01	0.00	1.00	1.00	1.96E-02 (vap)	No	No	No	0	0	0	0	0	0





Environment

Agency

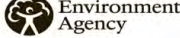
		Assessment Criterion (mg kg ⁻¹)			Ratio of ADE to HCV			Saturation Limit (mg kg ⁻¹)	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group					
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
21	Benzene	NR	1.26E+00	1.26E+00	0.00	1.00	1.00	4.01E+03 (sol)	No	No	No	No	No	No	No	No	
22	Xylene, p-	NR	3.50E+02	3.50E+02	0.00	1.00	1.00	2.65E+03 (sol)	No	No	No	No	No	No	No	No	
23	Dibenzofuran	2.41E+02	NR	NR	1.00	NR	NR	7.21E+02 (vap)	No	No	No	0	0	0	0	0	
24	Carbazole	5.23E+01	NR	NR	1.00	NR	NR	1.08E-02 (vap)	No	No	No	0	0	0	0	0	
25	2-Methylnaphthalene	2.44E+02	NR	NR	1.00	NR	NR	1.59E+03 (sol)	No	No	No	0	0	0	0	0	
26	1,2,4-Trimethylbenzene	NR	2.84E+00	NR	NR	1.00	NR	2.71E+03 (vap)	No	Yes	No	0	0	0	0	0	
27	2,4-Dinitrotoluene	1.46E+04	NR	NR	1.00	NR	NR	5.64E+02 (sol)	No	No	No	0	0	0	0	0	
28	Chloromethane	NR	1.75E-02	NR	NR	1.00	NR	2.77E+03 (sol)	No	Yes	No	0	0	0	0	0	
29	Trichloroethene (S4UL)	NR	6.73E-02	6.73E-02	0.00	1.00	1.00	6.02E+03 (vap)	No	No	No	0	0	0	0	0	
30	2,4-Dimethylphenol	1.46E+03	NR	NR	1.00	NR	NR	6.07E+03 (vap)	No	No	No	0	0	0	0	0	



	Soil Distribution				Media Concentrations													
	Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
	%	%	%	%	mg kg ⁻¹	mg m ⁻³	mg kg ⁻¹	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW
1 Aliphatic EC >8-10 (S4UL)	99.2	0.0	0.8	100.0	1.30E+02	6.11E+03	NA	NA	NA	2.23E-01	4.33E-04	0.00E+00	NA	NA	NA	NA	NA	NA
2 Aromatic EC >8-10 (S4UL)	99.3	0.6	0.1	100.0	2.31E+02	1.26E+03	NA	NA	NA	4.62E-02	2.63E-04	0.00E+00	NA	NA	NA	NA	NA	NA
3 Aromatic EC >10-12 (S4UL)	99.6	0.4	0.0	100.0	1.27E+03	1.26E+03	NA	NA	NA	4.62E-02	6.18E-04	0.00E+00	NA	NA	NA	NA	NA	NA
4 Aromatic EC >12-16 (S4UL)	99.8	0.2	0.0	100.0	1.42E+04	1.22E+03	NA	NA	NA	4.61E-02	2.07E-03	0.00E+00	NA	NA	NA	NA	NA	NA
5 Aromatic EC >16-21 (S4UL)	99.9	0.1	0.0	100.0	2.52E+05	4.27E+02	NA	NA	NA	2.28E-02	6.70E-03	0.00E+00	NA	NA	NA	NA	NA	NA
6 Aromatic EC >21-35 (S4UL)	100.0	0.0	0.0	100.0	2.13E+07	1.44E+02	NA	NA	NA	1.73E-02	1.28E-01	0.00E+00	NA	NA	NA	NA	NA	NA
7 Naphthalene (S4UL)	98.6	1.4	0.0	100.0	1.10E+01	3.84E+00	NA	NA	NA	1.06E-03	2.64E-06	0.00E+00	NA	NA	NA	NA	NA	NA
8 Acenaphthylene (S4UL)	99.5	0.5	0.0	100.0	2.28E+04	2.44E+02	NA	NA	NA	9.23E-02	1.18E-03	0.00E+00	NA	NA	NA	NA	NA	NA
9 Acenaphthene (S4UL)	99.6	0.4	0.0	100.0	2.43E+04	2.70E+02	NA	NA	NA	9.23E-02	1.19E-03	0.00E+00	NA	NA	NA	NA	NA	NA
10 Fluorene (S4UL)	99.7	0.3	0.0	100.0	3.07E+04	1.54E+02	NA	NA	NA	6.15E-02	1.13E-03	0.00E+00	NA	NA	NA	NA	NA	NA
11 Phenanthrene (S4UL)	99.8	0.2	0.0	100.0	3.59E+04	3.22E+01	NA	NA	NA	1.92E-02	7.64E-04	0.00E+00	NA	NA	NA	NA	NA	NA
12 Fluoranthene (S4UL)	99.9	0.1	0.0	100.0	2.01E+05	2.39E+01	NA	NA	NA	1.91E-02	2.12E-03	0.00E+00	NA	NA	NA	NA	NA	NA
13 Pyrene (S4UL)	99.9	0.1	0.0	100.0	4.60E+05	5.51E+01	NA	NA	NA	4.59E-02	5.13E-03	0.00E+00	NA	NA	NA	NA	NA	NA
14 Benzo(a)anthracene (S4UL)	100.0	0.0	0.0	100.0	1.68E+02	2.36E-03	NA	NA	NA	2.27E-06	8.01E-07	0.00E+00	NA	NA	NA	NA	NA	NA
15 Chrysene (S4UL)	100.0	0.0	0.0	100.0	1.64E+03	3.27E-03	NA	NA	NA	4.21E-06	8.97E-06	0.00E+00	NA	NA	NA	NA	NA	NA
16 Benzo(b)fluoranthene (S4UL)	100.0	0.0	0.0	100.0	5.52E+02	3.73E-04	NA	NA	NA	4.87E-07	2.14E-06	0.00E+00	NA	NA	NA	NA	NA	NA
17 Benzo(k)fluoranthene (S4UL)	100.0	0.0	0.0	100.0	2.25E+04	9.14E-03	NA	NA	NA	1.20E-05	7.34E-05	0.00E+00	NA	NA	NA	NA	NA	NA
18 Benzo(a)pyrene (S4UL)	100.0	0.0	0.0	100.0	5.91E+02	2.78E-04	NA	NA	NA	3.67E-07	2.08E-06	0.00E+00	NA	NA	NA	NA	NA	NA
19 Indeno(123-cd)pyrene (S4UL)	100.0	0.0	0.0	100.0	5.29E+03	4.30E-03	NA	NA	NA	5.61E-06	2.21E-05	0.00E+00	NA	NA	NA	NA	NA	NA
20 Dibenzo(ah)anthracene (S4UL)	100.0	0.0	0.0	100.0	3.37E+01	3.37E-05	NA	NA	NA	4.18E-08	9.53E-08	0.00E+00	NA	NA	NA	NA	NA	NA



 Environment Agency		Soil Distribution				Media Concentrations													
		Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
		%	%	%	%	mg kg ⁻¹	mg m ⁻³	mg kg ⁻¹	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW
21	Benzene	87.0	12.1	0.9	100.0	1.26E+00	6.48E+01	NA	NA	NA	2.15E-03	4.12E-06	0.00E+00	NA	NA	NA	NA	NA	NA
22	Xylene, p-	97.8	2.1	0.1	100.0	3.50E+02	2.83E+03	NA	NA	NA	7.93E-02	4.06E-04	0.00E+00	NA	NA	NA	NA	NA	NA
23	Dibenzofuran	99.9	0.1	0.0	100.0	2.41E+02	7.88E+00	NA	NA	NA	1.54E-03	1.43E-05	0.00E+00	NA	NA	NA	NA	NA	NA
24	Carbazole	98.8	1.2	0.0	100.0	5.23E+01	2.64E+00	NA	NA	NA	7.69E-04	4.92E-06	0.00E+00	NA	NA	NA	NA	NA	NA
25	2-Methylnaphthalene	99.6	0.4	0.0	100.0	2.44E+02	2.33E+01	NA	NA	NA	6.06E-03	2.94E-05	0.00E+00	NA	NA	NA	NA	NA	NA
26	1,2,4-Trimethylbenzene	99.3	0.7	0.0	100.0	2.84E+00	5.88E+00	NA	NA	NA	1.54E-03	1.60E-06	0.00E+00	NA	NA	NA	NA	NA	NA
27	2,4-Dinitrotoluene	93.8	6.2	0.0	100.0	1.46E+04	1.23E+00	NA	NA	NA	3.00E-03	1.69E-03	0.00E+00	NA	NA	NA	NA	NA	NA
28	Chloromethane	38.7	52.6	8.6	100.0	1.75E-02	9.12E+00	NA	NA	NA	3.96E-03	2.19E-07	0.00E+00	NA	NA	NA	NA	NA	NA
29	Trichloroethene (S4UL)	93.1	6.2	0.7	100.0	6.73E-02	2.86E+00	NA	NA	NA	8.77E-04	1.90E-07	0.00E+00	NA	NA	NA	NA	NA	NA
30	2,4-Dimethylphenol	96.5	3.5	0.0	100.0	1.46E+03	6.61E+01	NA	NA	NA	3.08E-02	1.80E-04	0.00E+00	NA	NA	NA	NA	NA	NA

		Average Daily Exposure (mg kg ⁻¹ bw day ⁻¹)						Distribution by Pathway (%)								
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
1	Aliphatic EC >8-10 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.45E-01	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	50.00	0.00	0.00	50.00
2	Aromatic EC >8-10 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.99	0.01	0.00	50.00
3	Aromatic EC >10-12 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.97	0.03	0.00	50.00
4	Aromatic EC >12-16 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.90	0.10	0.00	50.00
5	Aromatic EC >16-21 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-02	5.62E+95	0.00E+00	0.00	0.00	0.00	0.00	49.34	0.66	50.00	0.00
6	Aromatic EC >21-35 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-02	5.62E+95	0.00E+00	0.00	0.00	0.00	0.00	37.42	12.58	50.00	0.00
7	Naphthalene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.90E-04	3.94E-04	1.70E-04	0.00	0.00	0.00	0.00	80.26	0.01	0.00	19.74
8	Acenaphthylene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-02	7.88E-06	6.67E-07	0.00	0.00	0.00	0.00	99.94	0.06	0.00	0.00
9	Acenaphthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-02	5.51E-05	1.52E-06	0.00	0.00	0.00	0.00	99.94	0.06	0.00	0.00
10	Fluorene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-02	3.32E-05	5.82E-06	0.00	0.00	0.00	0.00	99.90	0.08	0.00	0.01
11	Phenanthrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02	8.66E-05	3.14E-05	0.00	0.00	0.00	0.00	99.57	0.18	0.00	0.25
12	Fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02	1.97E-05	5.09E-06	0.00	0.00	0.00	0.00	99.46	0.50	0.00	0.04
13	Pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	1.97E-05	3.94E-06	0.00	0.00	0.00	0.00	99.48	0.51	0.00	0.01
14	Benzo(a)anthracene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-06	3.38E-06	6.67E-07	0.00	0.00	0.00	0.00	98.42	1.58	0.00	0.00
15	Chrysene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-06	6.19E-06	1.03E-06	0.00	0.00	0.00	0.00	91.15	8.85	0.00	0.00
16	Benzo(b)fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E-07	6.19E-06	7.88E-07	0.00	0.00	0.00	0.00	83.33	16.67	0.00	0.00
17	Benzo(k)fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-05	5.06E-06	4.24E-07	0.00	0.00	0.00	0.00	78.27	21.73	0.00	0.00
18	Benzo(a)pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-07	6.19E-06	3.64E-07	0.00	0.00	0.00	0.00	79.50	20.50	0.00	0.00
19	Indeno(123-cd)pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.30E-06	5.63E-06	5.46E-07	0.00	0.00	0.00	0.00	84.76	15.24	0.00	0.00
20	Dibenzo(ah)anthracene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-08	2.25E-06	2.00E-06	0.00	0.00	0.00	0.00	90.60	9.40	0.00	0.00



		Average Daily Exposure (mg kg ⁻¹ bw day ⁻¹)							Distribution by Pathway (%)							
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
21	Benzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.99	0.01	0.00	0.00
22	Xylene, p-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.15E-02	6.19E-04	8.49E-03	0.00	0.00	0.00	0.00	85.84	0.02	0.00	14.14
23	Dibenzofuran	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.96	0.04	0.00	0.00
24	Carbazole	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.00E-04	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.97	0.03	0.00	0.00
25	2-Methylnaphthalene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.94E-03	0.00E+00	6.06E-05	0.00	0.00	0.00	0.00	98.46	0.02	0.00	1.52
26	1,2,4-Trimethylbenzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-03	1.35E-03	5.21E-03	0.00	0.00	0.00	0.00	50.00	0.00	10.29	39.71
27	2,4-Dinitrotoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	97.49	2.51	0.00	0.00
28	Chloromethane	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-03	0.00E+00	1.29E-02	0.00	0.00	0.00	0.00	50.00	0.00	0.00	50.00
29	Trichloroethene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.70E-04	5.63E-04	1.21E-02	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
30	2,4-Dimethylphenol	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-02	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.97	0.03	0.00	0.00



		Oral Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day ⁻¹)		Inhalation Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day ⁻¹)		Oral Mean Daily Intake ($\mu\text{g day}^{-1}$)		Inhalation Mean Daily Intake ($\mu\text{g day}^{-1}$)		Air-water partition coefficient (K_{ow}) ($\text{cm}^3 \text{cm}^{-3}$)		Coefficient of Diffusion in Air ($\text{m}^2 \text{s}^{-1}$)		Coefficient of Diffusion in Water ($\text{m}^2 \text{s}^{-1}$)		$\log K_{oc}$ ($\text{cm}^3 \text{g}^{-1}$)		$\log K_{ow}$ (dimensionless)		Dermal Absorption Fraction (dimensionless)		Soil-to-dust transport factor (g g^{-1} DW)		Sub-surface soil to indoor air correction factor (dimensionless)		Relative bioavailability via soil ingestion (unitless)		Relative bioavailability via dust inhalation (unitless)
1	Aliphatic EC >8-10 (S4UL)	TDI	100	TDI	290	9.99E+99		9.99E+99		4.15E+01		1.00E-05		1.00E-09		4.48		5.22		0.1		0.5		10		1		1
2	Aromatic EC >8-10 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		2.53E-01		1.00E-05		1.00E-09		3.2		3.69		0.1		0.5		10		1		1
3	Aromatic EC >10-12 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		7.22E-02		1.00E-05		1.00E-09		3.4		3.93		0.1		0.5		10		1		1
4	Aromatic EC >12-16 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		1.26E-02		1.00E-05		1.00E-09		3.7		4.29		0.1		0.5		10		1		1
5	Aromatic EC >16-21 (S4UL)	TDI	30	NR	0	9.99E+99		0		6.95E-04		1.00E-05		1.00E-09		4.15		4.82		0.1		0.5		10		1		1
6	Aromatic EC >21-35 (S4UL)	TDI	30	NR	0	9.99E+99		0		2.48E-05		1.00E-05		1.00E-09		5.1		5.95		0.1		0.5		10		1		1
7	Naphthalene (S4UL)	TDI	20	TDI	0.86	7		2.8		6.62E-03		6.52E-06		5.16E-10		2.81		3.34		0.13		0.5		1		1		1
8	Acenaphthylene (S4UL)	TDI	60	TDI	60	0.14		0.011		5.68E-04		5.97E-06		4.82E-10		3.26		3.91		0.13		0.5		1		1		1
9	Acenaphthene (S4UL)	TDI	60	TDI	60	0.98		0.025		7.59E-04		5.85E-06		4.70E-10		3.37		4.03		0.13		0.5		1		1		1
10	Fluorene (S4UL)	TDI	40	TDI	40	0.59		0.096		4.12E-04		5.58E-06		4.47E-10		3.45		4.13		0.13		0.5		1		1		1
11	Phenanthrene (S4UL)	TDI	12.5	TDI	12.5	1.54		0.518		1.43E-04		5.34E-06		4.32E-10		3.74		4.5		0.13		0.5		1		1		1
12	Fluoranthene (S4UL)	TDI	12.5	TDI	12.5	0.35		0.084		6.29E-05		5.01E-06		4.11E-10		4.26		5.13		0.13		0.5		1		1		1
13	Pyrene (S4UL)	TDI	30	TDI	30	0.35		0.065		5.64E-05		5.01E-06		4.15E-10		4.21		5.08		0.13		0.5		1		1		1
14	Benzo(a)anthracene (S4UL)	ID	0.155	ID	0.0015	0.06		0.011		3.16E-05		4.60E-06		3.80E-10		4.89		5.91		0.13		0.5		1		1		1
15	Chrysene (S4UL)	ID	0.31	ID	0.003	0.11		0.017		3.18E-06		4.57E-06		3.77E-10		4.74		5.73		0.13		0.5		1		1		1
16	Benzo(b)fluoranthene (S4UL)	ID	0.039	ID	0.00038	0.11		0.013		2.05E-06		4.36E-06		3.62E-10		5.02		6.08		0.13		0.5		1		1		1
17	Benzo(k)fluoranthene (S4UL)	ID	1.03	ID	0.01	0.09		0.007		1.74E-06		4.36E-06		3.62E-10		5.17		6.26		0.13		0.5		1		1		1
18	Benzo(a)pyrene (S4UL)	ID	0.031	ID	0.0003	0.11		0.006		1.76E-06		4.38E-06		3.67E-10		5.11		6.18		0.13		0.5		1		1		1
19	Indeno(123-cd)pyrene (S4UL)	ID	0.443	ID	0.0043	0.1		0.009		2.05E-06		4.17E-06		3.51E-10		4.94		5.97		0.13		0.5		1		1		1
20	Dibenzo(ah)anthracene (S4UL)	ID	0.0031	ID	0.00003	0.04		0.033		5.40E-06		4.08E-06		3.40E-10		5.27		6.38		0.13		0.5		1		1		1



		Oral Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day^{-1})	Inhalation Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day^{-1})	Oral Mean Daily Intake ($\mu\text{g day}^{-1}$)	Inhalation Mean Daily Intake ($\mu\text{g day}^{-1}$)	Air-water partition coefficient (K_{aw}) ($\text{cm}^3 \text{cm}^{-3}$)	Coefficient of Diffusion in Air ($\text{m}^2 \text{s}^{-1}$)	Coefficient of Diffusion in Water ($\text{m}^2 \text{s}^{-1}$)	$\log K_{oc}$ ($\text{cm}^3 \text{g}^{-1}$)	$\log K_{ow}$ (dimensionless)	Dermal Absorption Fraction (dimensionless)	Soil-to-dust transport factor (g g^{-1} DW)	Sub-surface soil to indoor air correction factor (dimensionless)	Relative bioavailability via soil ingestion (unitless)	Relative bioavailability via dust inhalation (unitless)
21	Benzene	ID 0.29	ID 1.4	NR	NR	1.16E-01	8.77E-06	6.64E-10	1.83	2.13	0.1	0.5	10	1	1
22	Xylene, p-	TDI 180	TDI 60	11	140	1.07E-01	7.04E-06	5.31E-10	2.65	3.15	0.1	0.5	10	1	1
23	Dibenzofuran	TDI 1	NR 0	0	0	8.71E-03	4.10E-06	7.38E-10	3.962	4.12	0.03	0.5	1	1	1
24	Carbazole	ID 0.5	NR 0	NR	NR	1.15E-03	5.39E-06	4.40E-10	2.89	3.6	0.1	0.5	1	1	1
25	2-Methylnaphthalene	TDI 4	NR NR	0	1	6.06E-03	6.03E-06	4.75E-10	3.34	4	0.13	0.5	1	1	1
26	1,2,4-Trimethylbenzene	NR 0	TDI 2	24	86	8.56E-02	6.44E-06	4.87E-10	3.15	3.76	0.1	0.5	1	1	1
27	2,4-Dinitrotoluene	TDI 2	NR 0	0	0	3.67E-07	5.71E-06	4.66E-10	2.15	1.98	0.102	0.5	1	1	1
28	Chloromethane	NR 0	TDI 5.14	0	212	2.71E-01	1.28E-05	9.70E-10	0.84	0.91	0.1	0.5	1	1	1
29	Trichloroethene (S4UL)	ID 0.5	ID 0.57	10	200	1.87E-01	7.91E-06	6.23E-10	2.15	2.53	0.1	0.5	1	1	1
30	2,4-Dimethylphenol	TDI 20	NR 0	0	0	3.57E-04	6.56E-06	5.15E-10	2.42	2.35	0.1	0.5	1	1	1



		Soil-to-water partition coefficient (cm ³ g ⁻¹)	Vapour pressure (Pa)	Water solubility (mg L ⁻¹)	Soil-to-plant concentration factor for green vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for root vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tree fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)
1	Aliphatic EC >8-10 (S4UL)	8.76E+02	3.20E+02	4.27E-01	model	model	model	model	model	model
2	Aromatic EC >8-10 (S4UL)	4.60E+01	3.20E+02	6.46E+01	model	model	model	model	model	model
3	Aromatic EC >10-12 (S4UL)	7.28E+01	3.21E+01	2.45E+01	model	model	model	model	model	model
4	Aromatic EC >12-16 (S4UL)	1.45E+02	1.14E+00	5.75E+00	model	model	model	model	model	model
5	Aromatic EC >16-21 (S4UL)	4.10E+02	5.62E-03	6.53E-01	model	model	model	model	model	model
6	Aromatic EC >21-35 (S4UL)	3.65E+03	1.61E-06	6.61E-03	model	model	model	model	model	model
7	Naphthalene (S4UL)	1.87E+01	2.31E+00	1.90E+01	model	model	model	model	model	model
8	Acenaphthylene (S4UL)	5.28E+01	7.08E-02	7.95E+00	model	model	model	model	model	model
9	Acenaphthene (S4UL)	6.80E+01	7.37E-02	4.11E+00	model	model	model	model	model	model
10	Fluorene (S4UL)	8.17E+01	1.56E-02	1.86E+00	model	model	model	model	model	model
11	Phenanthrene (S4UL)	1.59E+02	2.82E-03	1.12E+00	model	model	model	model	model	model
12	Fluoranthene (S4UL)	5.28E+02	1.31E-04	2.30E-01	model	model	model	model	model	model
13	Pyrene (S4UL)	4.70E+02	1.53E-05	1.30E-01	model	model	model	model	model	model
14	Benzo(a)anthracene (S4UL)	2.25E+03	1.24E-06	3.80E-03	model	model	model	model	model	model
15	Chrysene (S4UL)	1.59E+03	4.52E-08	2.00E-03	model	model	model	model	model	model
16	Benzo(b)fluoranthene (S4UL)	3.04E+03	6.34E-08	2.00E-03	model	model	model	model	model	model
17	Benzo(k)fluoranthene (S4UL)	4.29E+03	1.64E-08	8.00E-04	model	model	model	model	model	model
18	Benzo(a)pyrene (S4UL)	3.74E+03	2.00E-08	3.80E-03	model	model	model	model	model	model
19	Indeno(123-cd)pyrene (S4UL)	2.53E+03	2.12E-09	2.00E-04	model	model	model	model	model	model
20	Dibenzo(ah)anthracene (S4UL)	5.40E+03	1.66E-10	6.00E-04	model	model	model	model	model	model



		Soil-to-water partition coefficient (cm ³ g ⁻¹)	Vapour pressure (Pa)	Water solubility (mg L ⁻¹)	Soil-to-plant concentration factor for green vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for root vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tree fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)
21	Benzene	1.96E+00	6.24E+03	1.78E+03	model	model	model	0.00E+00	0.00E+00	model
22	Xylene, p-	1.30E+01	4.75E+02	2.00E+02	model	model	model	0.00E+00	0.00E+00	model
23	Dibenzofuran	2.66E+02	3.31E-01	3.10E+00	model	model	model	model	model	model
24	Carbazole	2.25E+01	7.64E-06	1.16E+00	Model	Model	Model	Model	Model	Model
25	2-Methylnaphthalene	6.34E+01	3.41E+00	2.50E+01	model	model	model	model	model	model
26	1,2,4-Trimethylbenzene	4.10E+01	1.10E+02	5.59E+02	Model	Model	Model	Model	Model	Model
27	2,4-Dinitrotoluene	4.10E+00	1.54E-02	1.29E+02	Model	Model	Model	Model	Model	Model
28	Chloromethane	2.01E-01	3.31E+05	5.35E+03	Model	Model	Model	Model	Model	Model
29	Trichloroethene (S4UL)	4.10E+00	4.58E+03	1.37E+03	model	model	model	0.00E+00	0.00E+00	model
30	2,4-Dimethylphenol	7.63E+00	5.28E+00	8.11E+03	Model	Model	Model	Model	Model	Model

CLEA Software Version 1.071

Page 1 of 11

Report generated 22-Sep-22

Report title Vapour Only GAC, Part 2 - 5% SOM

Created by Rob Reuter at Wardell Armstrong



RESULTS

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CLEA Software Version 1.071

Page 1 of 11

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21-Jul-22

Report title

Vapour Only GAC, Part 1 - 18% SOM

Created by

Rob Reuter at Wardell Armstrong



RESULTS



		Assessment Criterion (mg kg ⁻¹)			Ratio of ADE to HCV			Saturation Limit (mg kg ⁻¹)	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group					
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
1	Aliphatic EC >8-10 (S4UL)	NR	4.65E+02	4.65E+02	0.00	1.00	1.00	1.35E+03 (vap)	Yes	Yes	No	0	0	0	0	0	0
2	Aromatic EC >8-10 (S4UL)	NR	8.27E+02	8.27E+02	0.00	1.00	1.00	1.07E+04 (vap)	Yes	Yes	No	0	0	0	0	0	0
3	Aromatic EC >10-12 (S4UL)	NR	4.57E+03	4.57E+03	0.00	1.00	1.00	6.43E+03 (sol)	Yes	Yes	No	0	0	0	0	0	0
4	Aromatic EC >12-16 (S4UL)	NR	5.08E+04	5.08E+04	0.00	1.00	1.00	3.01E+03 (sol)	Yes	Yes	No	0	0	0	0	0	0
5	Aromatic EC >16-21 (S4UL)	8.97E+05	NR	NR	1.00	NR	NR	9.63E+02 (vap)	Yes	No	No	0	0	0	0	0	0
6	Aromatic EC >21-35 (S4UL)	6.24E+07	NR	NR	1.00	NR	NR	8.69E+01 (sol)	Yes	No	No	0	0	0	0	0	0
7	Naphthalene (S4UL)	NR	3.93E+01	NR	0.00	1.00	NR	1.29E+03 (sol)	No	No	No	0	0	0	0	0	0
8	Acenaphthylene (S4UL)	NR	8.18E+04	8.18E+04	0.00	1.00	1.00	1.51E+03 (sol)	No	No	No	0	0	0	0	0	0
9	Acenaphthene (S4UL)	NR	8.72E+04	8.72E+04	0.00	1.00	1.00	1.01E+03 (sol)	No	No	No	0	0	0	0	0	0
10	Fluorene (S4UL)	NR	1.10E+05	1.10E+05	0.00	1.00	1.00	5.48E+02 (sol)	No	No	No	0	0	0	0	0	0
11	Phenanthrene (S4UL)	NR	1.29E+05	1.29E+05	0.00	1.00	1.00	6.43E+02 (sol)	No	No	No	0	0	0	0	0	0
12	Fluoranthene (S4UL)	NR	7.19E+05	7.19E+05	0.00	1.00	1.00	3.40E+02 (vap)	No	No	No	0	0	0	0	0	0
13	Pyrene (S4UL)	NR	1.65E+06	1.65E+06	0.00	1.00	1.00	3.95E+01 (vap)	No	No	No	0	0	0	0	0	0
14	Benzo(a)anthracene (S4UL)	NR	5.96E+02	5.96E+02	0.00	1.00	1.00	3.08E+01 (sol)	No	No	No	0	0	0	0	0	0
15	Chrysene (S4UL)	NR	5.47E+03	5.47E+03	0.00	1.00	1.00	7.91E+00 (vap)	No	No	No	0	0	0	0	0	0
16	Benzo(b)fluoranthene (S4UL)	NR	1.73E+03	1.73E+03	0.00	1.00	1.00	2.19E+01 (sol)	No	No	No	0	0	0	0	0	0
17	Benzo(k)fluoranthene (S4UL)	NR	6.79E+04	6.79E+04	0.00	1.00	1.00	1.24E+01 (sol)	No	No	No	0	0	0	0	0	0
18	Benzo(a)pyrene (S4UL)	NR	1.80E+03	1.80E+03	0.00	1.00	1.00	1.64E+01 (vap)	No	No	No	0	0	0	0	0	0
19	Indeno(123-cd)pyrene (S4UL)	NR	1.68E+04	1.68E+04	0.00	1.00	1.00	1.10E+00 (vap)	No	No	No	0	0	0	0	0	0
20	Dibenzo(ah)anthracene (S4UL)	NR	1.12E+02	1.12E+02	0.00	1.00	1.00	7.07E-02 (vap)	No	No	No	0	0	0	0	0	0



		Assessment Criterion (mg kg ⁻¹)			Ratio of ADE to HCV			Saturation Limit (mg kg ⁻¹)	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group					
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
21	Benzene	NR	4.11E+00	4.11E+00	0.00	1.00	1.00	1.31E+04 (sol)	No	No	No	No	No	No	No	No	No
22	Xylene, p-	NR	1.24E+03	1.24E+03	0.00	1.00	1.00	9.38E+03 (sol)	No	No	No	No	No	No	No	No	No
23	Dibenzofuran	8.65E+02	NR	NR	1.00	NR	NR	2.59E+03 (vap)	No	No	No	0	0	0	0	0	0
24	Carbazole	1.87E+02	NR	NR	1.00	NR	NR	3.84E-02 (vap)	No	No	No	0	0	0	0	0	0
25	2-Methylnaphthalene	8.77E+02	NR	NR	1.00	NR	NR	5.72E+03 (sol)	No	No	No	0	0	0	0	0	0
26	1,2,4-Trimethylbenzene	NR	1.02E+01	NR	NR	1.00	NR	9.70E+03 (vap)	No	Yes	No	0	0	0	0	0	0
27	2,4-Dinitrotoluene	4.93E+04	NR	NR	1.00	NR	NR	1.94E+03 (sol)	No	No	No	0	0	0	0	0	0
28	Chloromethane	NR	3.50E-02	NR	NR	1.00	NR	5.56E+03 (sol)	No	Yes	No	0	0	0	0	0	0
29	Trichloroethene (S4UL)	NR	2.30E-01	2.30E-01	0.00	1.00	1.00	2.06E+04 (vap)	No	No	No	0	0	0	0	0	0
30	2,4-Dimethylphenol	5.13E+03	NR	NR	1.00	NR	NR	2.13E+04 (vap)	No	No	No	0	0	0	0	0	0



	Soil Distribution				Media Concentrations													
	Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
	%	%	%	%	mg kg ⁻¹	mg m ⁻³	mg kg ⁻¹	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW
1 Aliphatic EC >8-10 (S4UL)	99.8	0.0	0.2	100.0	4.65E+02	6.11E+03	NA	NA	NA	2.23E-01	8.20E-04	0.00E+00	NA	NA	NA	NA	NA	NA
2 Aromatic EC >8-10 (S4UL)	99.8	0.2	0.0	100.0	8.27E+02	1.26E+03	NA	NA	NA	4.62E-02	4.97E-04	0.00E+00	NA	NA	NA	NA	NA	NA
3 Aromatic EC >10-12 (S4UL)	99.9	0.1	0.0	100.0	4.57E+03	1.26E+03	NA	NA	NA	4.61E-02	1.17E-03	0.00E+00	NA	NA	NA	NA	NA	NA
4 Aromatic EC >12-16 (S4UL)	99.9	0.1	0.0	100.0	5.08E+04	1.22E+03	NA	NA	NA	4.60E-02	3.91E-03	0.00E+00	NA	NA	NA	NA	NA	NA
5 Aromatic EC >16-21 (S4UL)	100.0	0.0	0.0	100.0	8.97E+05	4.22E+02	NA	NA	NA	2.25E-02	1.26E-02	0.00E+00	NA	NA	NA	NA	NA	NA
6 Aromatic EC >21-35 (S4UL)	100.0	0.0	0.0	100.0	6.24E+07	1.18E+02	NA	NA	NA	1.41E-02	1.97E-01	0.00E+00	NA	NA	NA	NA	NA	NA
7 Naphthalene (S4UL)	99.6	0.4	0.0	100.0	3.93E+01	3.84E+00	NA	NA	NA	1.06E-03	4.98E-06	0.00E+00	NA	NA	NA	NA	NA	NA
8 Acenaphthylene (S4UL)	99.9	0.1	0.0	100.0	8.18E+04	2.44E+02	NA	NA	NA	9.23E-02	2.23E-03	0.00E+00	NA	NA	NA	NA	NA	NA
9 Acenaphthene (S4UL)	99.9	0.1	0.0	100.0	8.72E+04	2.70E+02	NA	NA	NA	9.22E-02	2.26E-03	0.00E+00	NA	NA	NA	NA	NA	NA
10 Fluorene (S4UL)	99.9	0.1	0.0	100.0	1.10E+05	1.54E+02	NA	NA	NA	6.15E-02	2.13E-03	0.00E+00	NA	NA	NA	NA	NA	NA
11 Phenanthrene (S4UL)	100.0	0.0	0.0	100.0	1.29E+05	3.21E+01	NA	NA	NA	1.91E-02	1.45E-03	0.00E+00	NA	NA	NA	NA	NA	NA
12 Fluoranthene (S4UL)	100.0	0.0	0.0	100.0	7.19E+05	2.38E+01	NA	NA	NA	1.91E-02	4.01E-03	0.00E+00	NA	NA	NA	NA	NA	NA
13 Pyrene (S4UL)	100.0	0.0	0.0	100.0	1.65E+06	5.48E+01	NA	NA	NA	4.57E-02	9.70E-03	0.00E+00	NA	NA	NA	NA	NA	NA
14 Benzo(a)anthracene (S4UL)	100.0	0.0	0.0	100.0	5.96E+02	2.33E-03	NA	NA	NA	2.24E-06	1.50E-06	0.00E+00	NA	NA	NA	NA	NA	NA
15 Chrysene (S4UL)	100.0	0.0	0.0	100.0	5.47E+03	3.03E-03	NA	NA	NA	3.90E-06	1.58E-05	0.00E+00	NA	NA	NA	NA	NA	NA
16 Benzo(b)fluoranthene (S4UL)	100.0	0.0	0.0	100.0	1.73E+03	3.24E-04	NA	NA	NA	4.24E-07	3.53E-06	0.00E+00	NA	NA	NA	NA	NA	NA
17 Benzo(k)fluoranthene (S4UL)	100.0	0.0	0.0	100.0	6.79E+04	7.65E-03	NA	NA	NA	1.01E-05	1.17E-04	0.00E+00	NA	NA	NA	NA	NA	NA
18 Benzo(a)pyrene (S4UL)	100.0	0.0	0.0	100.0	1.80E+03	2.35E-04	NA	NA	NA	3.10E-07	3.33E-06	0.00E+00	NA	NA	NA	NA	NA	NA
19 Indeno(123-cd)pyrene (S4UL)	100.0	0.0	0.0	100.0	1.68E+04	3.78E-03	NA	NA	NA	4.94E-06	3.70E-05	0.00E+00	NA	NA	NA	NA	NA	NA
20 Dibenzo(ah)anthracene (S4UL)	100.0	0.0	0.0	100.0	1.12E+02	3.11E-05	NA	NA	NA	3.86E-08	1.67E-07	0.00E+00	NA	NA	NA	NA	NA	NA



 Environment Agency		Soil Distribution				Media Concentrations													
						Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables
		%	%	%	%	mg kg ⁻¹	mg m ⁻³	mg kg ⁻¹	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW
21	Benzene	96.0	3.7	0.3	100.0	4.11E+00	6.48E+01	NA	NA	NA	2.15E-03	7.45E-06	0.00E+00	NA	NA	NA	NA	NA	NA
22	Xylene, p-	99.4	0.6	0.0	100.0	1.24E+03	2.82E+03	NA	NA	NA	7.93E-02	7.65E-04	0.00E+00	NA	NA	NA	NA	NA	NA
23	Dibenzofuran	100.0	0.0	0.0	100.0	8.65E+02	7.88E+00	NA	NA	NA	1.54E-03	2.71E-05	0.00E+00	NA	NA	NA	NA	NA	NA
24	Carbazole	99.7	0.3	0.0	100.0	1.87E+02	2.64E+00	NA	NA	NA	7.69E-04	9.30E-06	0.00E+00	NA	NA	NA	NA	NA	NA
25	2-Methylnaphthalene	99.9	0.1	0.0	100.0	8.77E+02	2.32E+01	NA	NA	NA	6.06E-03	5.58E-05	0.00E+00	NA	NA	NA	NA	NA	NA
26	1,2,4-Trimethylbenzene	99.8	0.2	0.0	100.0	1.02E+01	5.88E+00	NA	NA	NA	1.54E-03	3.03E-06	0.00E+00	NA	NA	NA	NA	NA	NA
27	2,4-Dinitrotoluene	98.2	1.8	0.0	100.0	4.93E+04	1.20E+00	NA	NA	NA	2.94E-03	3.07E-03	0.00E+00	NA	NA	NA	NA	NA	NA
28	Chloromethane	69.5	26.2	4.3	100.0	3.50E-02	9.12E+00	NA	NA	NA	3.96E-03	3.11E-07	0.00E+00	NA	NA	NA	NA	NA	NA
29	Trichloroethene (S4UL)	98.0	1.8	0.2	100.0	2.30E-01	2.86E+00	NA	NA	NA	8.77E-04	3.51E-07	0.00E+00	NA	NA	NA	NA	NA	NA
30	2,4-Dimethylphenol	99.0	1.0	0.0	100.0	5.13E+03	6.61E+01	NA	NA	NA	3.08E-02	3.38E-04	0.00E+00	NA	NA	NA	NA	NA	NA

		Average Daily Exposure (mg kg ⁻¹ bw day ⁻¹)							Distribution by Pathway (%)							
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
1	Aliphatic EC >8-10 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.45E-01	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.99	0.01	0.00	50.00
2	Aromatic EC >8-10 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.98	0.02	0.00	50.00
3	Aromatic EC >10-12 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.94	0.06	0.00	50.00
4	Aromatic EC >12-16 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	49.81	0.19	0.00	50.00
5	Aromatic EC >16-21 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-02	5.62E+95	0.00E+00	0.00	0.00	0.00	0.00	48.76	1.24	50.00	0.00
6	Aromatic EC >21-35 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-02	5.62E+95	0.00E+00	0.00	0.00	0.00	0.00	30.53	19.47	50.00	0.00
7	Naphthalene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.90E-04	3.94E-04	1.70E-04	0.00	0.00	0.00	0.00	80.25	0.02	0.00	19.74
8	Acenaphthylene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-02	7.88E-06	6.67E-07	0.00	0.00	0.00	0.00	99.89	0.11	0.00	0.00
9	Acenaphthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-02	5.51E-05	1.52E-06	0.00	0.00	0.00	0.00	99.89	0.11	0.00	0.00
10	Fluorene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-02	3.32E-05	5.82E-06	0.00	0.00	0.00	0.00	99.83	0.16	0.00	0.01
11	Phenanthrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02	8.66E-05	3.14E-05	0.00	0.00	0.00	0.00	99.41	0.34	0.00	0.25
12	Fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02	1.97E-05	5.09E-06	0.00	0.00	0.00	0.00	99.01	0.95	0.00	0.04
13	Pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	1.97E-05	3.94E-06	0.00	0.00	0.00	0.00	99.03	0.96	0.00	0.01
14	Benzo(a)anthracene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-06	3.38E-06	6.67E-07	0.00	0.00	0.00	0.00	97.05	2.95	0.00	0.00
15	Chrysene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-06	6.19E-06	1.03E-06	0.00	0.00	0.00	0.00	84.45	15.55	0.00	0.00
16	Benzo(b)fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E-07	6.19E-06	7.88E-07	0.00	0.00	0.00	0.00	72.48	27.52	0.00	0.00
17	Benzo(k)fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-05	5.06E-06	4.24E-07	0.00	0.00	0.00	0.00	65.50	34.50	0.00	0.00
18	Benzo(a)pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-07	6.19E-06	3.64E-07	0.00	0.00	0.00	0.00	67.15	32.85	0.00	0.00
19	Indeno(123-cd)pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.30E-06	5.63E-06	5.46E-07	0.00	0.00	0.00	0.00	74.57	25.43	0.00	0.00
20	Dibenzo(ah)anthracene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-08	2.25E-06	2.00E-06	0.00	0.00	0.00	0.00	83.55	16.45	0.00	0.00



		Average Daily Exposure (mg kg ⁻¹ bw day ⁻¹)							Distribution by Pathway (%)							
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
21	Benzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.98	0.02	0.00	0.00
22	Xylene, p-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.15E-02	6.19E-04	8.49E-03	0.00	0.00	0.00	0.00	85.82	0.04	0.00	14.14
23	Dibenzofuran	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.92	0.08	0.00	0.00
24	Carbazole	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.00E-04	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.94	0.06	0.00	0.00
25	2-Methylnaphthalene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.94E-03	0.00E+00	6.06E-05	0.00	0.00	0.00	0.00	98.44	0.04	0.00	1.52
26	1,2,4-Trimethylbenzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-03	1.35E-03	5.21E-03	0.00	0.00	0.00	0.00	50.00	0.00	10.29	39.71
27	2,4-Dinitrotoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	95.45	4.55	0.00	0.00
28	Chloromethane	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-03	0.00E+00	1.29E-02	0.00	0.00	0.00	0.00	50.00	0.00	0.00	50.00
29	Trichloroethene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.70E-04	5.63E-04	1.21E-02	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
30	2,4-Dimethylphenol	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-02	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	99.95	0.05	0.00	0.00



		Oral Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day ⁻¹)		Inhalation Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day ⁻¹)		Oral Mean Daily Intake ($\mu\text{g day}^{-1}$)		Inhalation Mean Daily Intake ($\mu\text{g day}^{-1}$)		Air-water partition coefficient (K_{ow}) ($\text{cm}^3 \text{cm}^{-3}$)		Coefficient of Diffusion in Air ($\text{m}^2 \text{s}^{-1}$)		Coefficient of Diffusion in Water ($\text{m}^2 \text{s}^{-1}$)		$\log K_{oc}$ ($\text{cm}^3 \text{g}^{-1}$)		$\log K_{ow}$ (dimensionless)		Dermal Absorption Fraction (dimensionless)		Soil-to-dust transport factor (g g^{-1} DW)		Sub-surface soil to indoor air correction factor (dimensionless)		Relative bioavailability via soil ingestion (unitless)		Relative bioavailability via dust inhalation (unitless)
1	Aliphatic EC >8-10 (S4UL)	TDI	100	TDI	290	9.99E+99		9.99E+99		4.15E+01		1.00E-05		1.00E-09		4.48		5.22		0.1		0.5		10		1		1
2	Aromatic EC >8-10 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		2.53E-01		1.00E-05		1.00E-09		3.2		3.69		0.1		0.5		10		1		1
3	Aromatic EC >10-12 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		7.22E-02		1.00E-05		1.00E-09		3.4		3.93		0.1		0.5		10		1		1
4	Aromatic EC >12-16 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		1.26E-02		1.00E-05		1.00E-09		3.7		4.29		0.1		0.5		10		1		1
5	Aromatic EC >16-21 (S4UL)	TDI	30	NR	0	9.99E+99		0		6.95E-04		1.00E-05		1.00E-09		4.15		4.82		0.1		0.5		10		1		1
6	Aromatic EC >21-35 (S4UL)	TDI	30	NR	0	9.99E+99		0		2.48E-05		1.00E-05		1.00E-09		5.1		5.95		0.1		0.5		10		1		1
7	Naphthalene (S4UL)	TDI	20	TDI	0.86	7		2.8		6.62E-03		6.52E-06		5.16E-10		2.81		3.34		0.13		0.5		1		1		1
8	Acenaphthylene (S4UL)	TDI	60	TDI	60	0.14		0.011		5.68E-04		5.97E-06		4.82E-10		3.26		3.91		0.13		0.5		1		1		1
9	Acenaphthene (S4UL)	TDI	60	TDI	60	0.98		0.025		7.59E-04		5.85E-06		4.70E-10		3.37		4.03		0.13		0.5		1		1		1
10	Fluorene (S4UL)	TDI	40	TDI	40	0.59		0.096		4.12E-04		5.58E-06		4.47E-10		3.45		4.13		0.13		0.5		1		1		1
11	Phenanthrene (S4UL)	TDI	12.5	TDI	12.5	1.54		0.518		1.43E-04		5.34E-06		4.32E-10		3.74		4.5		0.13		0.5		1		1		1
12	Fluoranthene (S4UL)	TDI	12.5	TDI	12.5	0.35		0.084		6.29E-05		5.01E-06		4.11E-10		4.26		5.13		0.13		0.5		1		1		1
13	Pyrene (S4UL)	TDI	30	TDI	30	0.35		0.065		5.64E-05		5.01E-06		4.15E-10		4.21		5.08		0.13		0.5		1		1		1
14	Benzo(a)anthracene (S4UL)	ID	0.155	ID	0.0015	0.06		0.011		3.16E-05		4.60E-06		3.80E-10		4.89		5.91		0.13		0.5		1		1		1
15	Chrysene (S4UL)	ID	0.31	ID	0.003	0.11		0.017		3.18E-06		4.57E-06		3.77E-10		4.74		5.73		0.13		0.5		1		1		1
16	Benzo(b)fluoranthene (S4UL)	ID	0.039	ID	0.00038	0.11		0.013		2.05E-06		4.36E-06		3.62E-10		5.02		6.08		0.13		0.5		1		1		1
17	Benzo(k)fluoranthene (S4UL)	ID	1.03	ID	0.01	0.09		0.007		1.74E-06		4.36E-06		3.62E-10		5.17		6.26		0.13		0.5		1		1		1
18	Benzo(a)pyrene (S4UL)	ID	0.031	ID	0.0003	0.11		0.006		1.76E-06		4.38E-06		3.67E-10		5.11		6.18		0.13		0.5		1		1		1
19	Indeno(123-cd)pyrene (S4UL)	ID	0.443	ID	0.0043	0.1		0.009		2.05E-06		4.17E-06		3.51E-10		4.94		5.97		0.13		0.5		1		1		1
20	Dibenzo(ah)anthracene (S4UL)	ID	0.0031	ID	0.00003	0.04		0.033		5.40E-06		4.08E-06		3.40E-10		5.27		6.38		0.13		0.5		1		1		1



		Oral Health Criteria Value ($\mu\text{g kg}^{-1} \text{ BW day}^{-1}$)	Inhalation Health Criteria Value ($\mu\text{g kg}^{-1} \text{ BW day}^{-1}$)	Oral Mean Daily Intake ($\mu\text{g day}^{-1}$)	Inhalation Mean Daily Intake ($\mu\text{g day}^{-1}$)	Air-water partition coefficient (K_{aw}) ($\text{cm}^3 \text{ cm}^{-3}$)	Coefficient of Diffusion in Air ($\text{m}^2 \text{ s}^{-1}$)	Coefficient of Diffusion in Water ($\text{m}^2 \text{ s}^{-1}$)	$\log K_{oc}$ ($\text{cm}^3 \text{ g}^{-1}$)	$\log K_{ow}$ (dimensionless)	Dermal Absorption Fraction (dimensionless)	Soil-to-dust transport factor ($\text{g g}^{-1} \text{ DW}$)	Sub-surface soil to indoor air correction factor (dimensionless)	Relative bioavailability via soil ingestion (unitless)	Relative bioavailability via dust inhalation (unitless)
21	Benzene	ID 0.29	ID 1.4	NR	NR	1.16E-01	8.77E-06	6.64E-10	1.83	2.13	0.1	0.5	10	1	1
22	Xylene, p-	TDI 180	TDI 60	11	140	1.07E-01	7.04E-06	5.31E-10	2.65	3.15	0.1	0.5	10	1	1
23	Dibenzofuran	TDI 1	NR 0	0	0	8.71E-03	4.10E-06	7.38E-10	3.962	4.12	0.03	0.5	1	1	1
24	Carbazole	ID 0.5	NR 0	NR	NR	1.15E-03	5.39E-06	4.40E-10	2.89	3.6	0.1	0.5	1	1	1
25	2-Methylnaphthalene	TDI 4	NR NR	0	1	6.06E-03	6.03E-06	4.75E-10	3.34	4	0.13	0.5	1	1	1
26	1,2,4-Trimethylbenzene	NR 0	TDI 2	24	86	8.56E-02	6.44E-06	4.87E-10	3.15	3.76	0.1	0.5	1	1	1
27	2,4-Dinitrotoluene	TDI 2	NR 0	0	0	3.67E-07	5.71E-06	4.66E-10	2.15	1.98	0.102	0.5	1	1	1
28	Chloromethane	NR 0	TDI 5.14	0	212	2.71E-01	1.28E-05	9.70E-10	0.84	0.91	0.1	0.5	1	1	1
29	Trichloroethene (S4UL)	ID 0.5	ID 0.57	10	200	1.87E-01	7.91E-06	6.23E-10	2.15	2.53	0.1	0.5	1	1	1
30	2,4-Dimethylphenol	TDI 20	NR 0	0	0	3.57E-04	6.56E-06	5.15E-10	2.42	2.35	0.1	0.5	1	1	1



		Soil-to-water partition coefficient (cm ³ g ⁻¹)	Vapour pressure (Pa)	Water solubility (mg L ⁻¹)	Soil-to-plant concentration factor for green vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for root vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tree fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)
1	Aliphatic EC >8-10 (S4UL)	3.15E+03	3.20E+02	4.27E-01	model	model	model	model	model	model
2	Aromatic EC >8-10 (S4UL)	1.65E+02	3.20E+02	6.46E+01	model	model	model	model	model	model
3	Aromatic EC >10-12 (S4UL)	2.62E+02	3.21E+01	2.45E+01	model	model	model	model	model	model
4	Aromatic EC >12-16 (S4UL)	5.23E+02	1.14E+00	5.75E+00	model	model	model	model	model	model
5	Aromatic EC >16-21 (S4UL)	1.47E+03	5.62E-03	6.53E-01	model	model	model	model	model	model
6	Aromatic EC >21-35 (S4UL)	1.31E+04	1.61E-06	6.61E-03	model	model	model	model	model	model
7	Naphthalene (S4UL)	6.74E+01	2.31E+00	1.90E+01	model	model	model	model	model	model
8	Acenaphthylene (S4UL)	1.90E+02	7.08E-02	7.95E+00	model	model	model	model	model	model
9	Acenaphthene (S4UL)	2.45E+02	7.37E-02	4.11E+00	model	model	model	model	model	model
10	Fluorene (S4UL)	2.94E+02	1.56E-02	1.86E+00	model	model	model	model	model	model
11	Phenanthrene (S4UL)	5.74E+02	2.82E-03	1.12E+00	model	model	model	model	model	model
12	Fluoranthene (S4UL)	1.90E+03	1.31E-04	2.30E-01	model	model	model	model	model	model
13	Pyrene (S4UL)	1.69E+03	1.53E-05	1.30E-01	model	model	model	model	model	model
14	Benzo(a)anthracene (S4UL)	8.10E+03	1.24E-06	3.80E-03	model	model	model	model	model	model
15	Chrysene (S4UL)	5.74E+03	4.52E-08	2.00E-03	model	model	model	model	model	model
16	Benzo(b)fluoranthene (S4UL)	1.09E+04	6.34E-08	2.00E-03	model	model	model	model	model	model
17	Benzo(k)fluoranthene (S4UL)	1.54E+04	1.64E-08	8.00E-04	model	model	model	model	model	model
18	Benzo(a)pyrene (S4UL)	1.34E+04	2.00E-08	3.80E-03	model	model	model	model	model	model
19	Indeno(123-cd)pyrene (S4UL)	9.09E+03	2.12E-09	2.00E-04	model	model	model	model	model	model
20	Dibenzo(ah)anthracene (S4UL)	1.94E+04	1.66E-10	6.00E-04	model	model	model	model	model	model



		Soil-to-water partition coefficient (cm ³ g ⁻¹)	Vapour pressure (Pa)	Water solubility (mg L ⁻¹)	Soil-to-plant concentration factor for green vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for root vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tree fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)
21	Benzene	7.06E+00	6.24E+03	1.78E+03	model	model	model	0.00E+00	0.00E+00	model
22	Xylene, p-	4.66E+01	4.75E+02	2.00E+02	model	model	model	0.00E+00	0.00E+00	model
23	Dibenzofuran	9.56E+02	3.31E-01	3.10E+00	model	model	model	model	model	model
24	Carbazole	8.10E+01	7.64E-06	1.16E+00	Model	Model	Model	Model	Model	Model
25	2-Methylnaphthalene	2.28E+02	3.41E+00	2.50E+01	model	model	model	model	model	model
26	1,2,4-Trimethylbenzene	1.47E+02	1.10E+02	5.59E+02	Model	Model	Model	Model	Model	Model
27	2,4-Dinitrotoluene	1.47E+01	1.54E-02	1.29E+02	Model	Model	Model	Model	Model	Model
28	Chloromethane	7.22E-01	3.31E+05	5.35E+03	Model	Model	Model	Model	Model	Model
29	Trichloroethene (S4UL)	1.47E+01	4.58E+03	1.37E+03	model	model	model	0.00E+00	0.00E+00	model
30	2,4-Dimethylphenol	2.75E+01	5.28E+00	8.11E+03	Model	Model	Model	Model	Model	Model

CLEA Software Version 1.071

Page 1 of 11

Report generated 22-Sep-22

Report title Vapour Only GAC, Part 2 - 18% SOM

Created by Rob Reuter at Wardell Armstrong



RESULTS

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Page 1 of 11

Report generated

21-Jul-22

Report title

Outdoor Vapour Only GAC, Part 1

Created by

Rob Reuter at Wardell Armstrong



Environment
Agency

RESULTS



		Assessment Criterion (mg kg ⁻¹)			Ratio of ADE to HCV			Saturation Limit (mg kg ⁻¹)	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group					
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
1	Aliphatic EC >8-10 (S4UL)	NR	6.68E+05	6.68E+05	0.00	1.00	1.00	7.77E+01 (vap)	Yes	Yes	No	0	0	0	0	0	0
2	Aromatic EC >8-10 (S4UL)	NR	4.04E+05	4.04E+05	0.00	1.00	1.00	6.13E+02 (vap)	Yes	Yes	No	0	0	0	0	0	0
3	Aromatic EC >10-12 (S4UL)	NR	9.42E+05	9.42E+05	0.00	1.00	1.00	3.64E+02 (sol)	Yes	Yes	No	0	0	0	0	0	0
4	Aromatic EC >12-16 (S4UL)	NR	3.12E+06	3.12E+06	0.00	1.00	1.00	1.69E+02 (sol)	Yes	Yes	No	0	0	0	0	0	0
5	Aromatic EC >16-21 (S4UL)	8.53E+06	NR	NR	1.00	NR	NR	5.37E+01 (vap)	Yes	No	No	0	0	0	0	0	0
6	Aromatic EC >21-35 (S4UL)	3.78E+07	NR	NR	1.00	NR	NR	4.83E+00 (sol)	Yes	No	No	0	0	0	0	0	0
7	Naphthalene (S4UL)	NR	4.49E+04	NR	0.00	1.00	NR	7.64E+01 (sol)	No	No	No	0	0	0	0	0	0
8	Acenaphthylene (S4UL)	NR	1.78E+07	1.78E+07	0.00	1.00	1.00	8.61E+01 (sol)	No	No	No	0	0	0	0	0	0
9	Acenaphthene (S4UL)	NR	1.86E+07	1.86E+07	0.00	1.00	1.00	5.70E+01 (sol)	No	No	No	0	0	0	0	0	0
10	Fluorene (S4UL)	NR	1.66E+07	1.66E+07	0.00	1.00	1.00	3.09E+01 (sol)	No	No	No	0	0	0	0	0	0
11	Phenanthrene (S4UL)	NR	8.89E+06	8.89E+06	0.00	1.00	1.00	3.60E+01 (sol)	No	No	No	0	0	0	0	0	0
12	Fluoranthene (S4UL)	NR	1.79E+07	1.79E+07	0.00	1.00	1.00	1.89E+01 (vap)	No	No	No	0	0	0	0	0	0
13	Pyrene (S4UL)	NR	4.06E+07	4.06E+07	0.00	1.00	1.00	2.20E+00 (vap)	No	No	No	0	0	0	0	0	0
14	Benzo(a)anthracene (S4UL)	NR	4.76E+03	4.76E+03	0.00	1.00	1.00	1.71E+00 (sol)	No	No	No	0	0	0	0	0	0
15	Chrysene (S4UL)	NR	8.30E+03	8.30E+03	0.00	1.00	1.00	4.40E-01 (vap)	No	No	No	0	0	0	0	0	0
16	Benzo(b)fluoranthene (S4UL)	NR	1.48E+03	1.48E+03	0.00	1.00	1.00	1.22E+00 (sol)	No	No	No	0	0	0	0	0	0
17	Benzo(k)fluoranthene (S4UL)	NR	4.64E+04	4.64E+04	0.00	1.00	1.00	6.87E-01 (sol)	No	No	No	0	0	0	0	0	0
18	Benzo(a)pyrene (S4UL)	NR	1.29E+03	1.29E+03	0.00	1.00	1.00	9.11E-01 (vap)	No	No	No	0	0	0	0	0	0
19	Indeno(123-cd)pyrene (S4UL)	NR	1.55E+04	1.55E+04	0.00	1.00	1.00	6.13E-02 (vap)	No	No	No	0	0	0	0	0	0
20	Dibenzo(ah)anthracene (S4UL)	NR	1.60E+02	1.60E+02	0.00	1.00	1.00	3.93E-03 (vap)	No	No	No	0	0	0	0	0	0



		Assessment Criterion (mg kg ⁻¹)			Ratio of ADE to HCV			Saturation Limit (mg kg ⁻¹)	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group					
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
21	Benzene	NR	7.96E+03	7.96E+03	0.00	1.00	1.00	1.22E+03 (sol)	No	No	No	No	No	No	No	No	No
22	Xylene, p-	NR	6.99E+05	6.99E+05	0.00	1.00	1.00	5.76E+02 (sol)	No	No	No	No	No	No	No	No	No
23	Dibenzofuran	2.55E+05	NR	NR	1.00	NR	NR	1.45E+02 (vap)	No	No	No	0	0	0	0	0	0
24	Carbazole	8.22E+04	NR	NR	1.00	NR	NR	2.25E-03 (vap)	No	No	No	0	0	0	0	0	0
25	2-Methylnaphthalene	4.99E+05	NR	NR	1.00	NR	NR	3.24E+02 (sol)	No	No	No	0	0	0	0	0	0
26	1,2,4-Trimethylbenzene	NR	2.72E+04	NR	NR	1.00	NR	5.57E+02 (vap)	No	Yes	No	0	0	0	0	0	0
27	2,4-Dinitrotoluene	2.92E+05	NR	NR	1.00	NR	NR	1.41E+02 (sol)	No	No	No	0	0	0	0	0	0
28	Chloromethane	NR	5.74E+03	NR	NR	1.00	NR	1.91E+03 (sol)	No	Yes	No	0	0	0	0	0	0
29	Trichloroethene (S4UL)	NR	3.45E+03	3.45E+03	0.00	1.00	1.00	1.54E+03 (vap)	No	No	No	0	0	0	0	0	0
30	2,4-Dimethylphenol	2.62E+06	NR	NR	1.00	NR	NR	1.38E+03 (vap)	No	No	No	0	0	0	0	0	0



	Soil Distribution				Media Concentrations													
	Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
	%	%	%	%	mg kg ⁻¹	mg m ⁻³	mg kg ⁻¹	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW
1 Aliphatic EC >8-10 (S4UL)	96.1	0.1	3.8	100.0	6.68E+05	1.52E+08	NA	NA	NA	NA	4.90E+00	0.00E+00	NA	NA	NA	NA	NA	NA
2 Aromatic EC >8-10 (S4UL)	96.7	2.9	0.4	100.0	4.04E+05	1.07E+07	NA	NA	NA	NA	1.01E+00	0.00E+00	NA	NA	NA	NA	NA	NA
3 Aromatic EC >10-12 (S4UL)	98.1	1.8	0.1	100.0	9.42E+05	4.58E+06	NA	NA	NA	NA	1.01E+00	0.00E+00	NA	NA	NA	NA	NA	NA
4 Aromatic EC >12-16 (S4UL)	99.1	0.9	0.0	100.0	3.12E+06	1.34E+06	NA	NA	NA	NA	1.01E+00	0.00E+00	NA	NA	NA	NA	NA	NA
5 Aromatic EC >16-21 (S4UL)	99.7	0.3	0.0	100.0	8.53E+06	7.21E+04	NA	NA	NA	NA	5.07E-01	0.00E+00	NA	NA	NA	NA	NA	NA
6 Aromatic EC >21-35 (S4UL)	100.0	0.0	0.0	100.0	3.78E+07	1.28E+03	NA	NA	NA	NA	5.07E-01	0.00E+00	NA	NA	NA	NA	NA	NA
7 Naphthalene (S4UL)	93.2	6.8	0.0	100.0	4.49E+04	7.39E+04	NA	NA	NA	NA	2.33E-02	0.00E+00	NA	NA	NA	NA	NA	NA
8 Acenaphthylene (S4UL)	97.5	2.5	0.0	100.0	1.78E+07	9.33E+05	NA	NA	NA	NA	2.03E+00	0.00E+00	NA	NA	NA	NA	NA	NA
9 Acenaphthene (S4UL)	98.0	2.0	0.0	100.0	1.86E+07	1.02E+06	NA	NA	NA	NA	2.03E+00	0.00E+00	NA	NA	NA	NA	NA	NA
10 Fluorene (S4UL)	98.4	1.6	0.0	100.0	1.66E+07	4.11E+05	NA	NA	NA	NA	1.35E+00	0.00E+00	NA	NA	NA	NA	NA	NA
11 Phenanthrene (S4UL)	99.2	0.8	0.0	100.0	8.89E+06	3.95E+04	NA	NA	NA	NA	4.21E-01	0.00E+00	NA	NA	NA	NA	NA	NA
12 Fluoranthene (S4UL)	99.7	0.3	0.0	100.0	1.79E+07	1.06E+04	NA	NA	NA	NA	4.22E-01	0.00E+00	NA	NA	NA	NA	NA	NA
13 Pyrene (S4UL)	99.7	0.3	0.0	100.0	4.06E+07	2.43E+04	NA	NA	NA	NA	1.01E+00	0.00E+00	NA	NA	NA	NA	NA	NA
14 Benzo(a)anthracene (S4UL)	99.9	0.1	0.0	100.0	4.76E+03	3.34E-01	NA	NA	NA	NA	5.07E-05	0.00E+00	NA	NA	NA	NA	NA	NA
15 Chrysene (S4UL)	99.9	0.1	0.0	100.0	8.30E+03	8.27E-02	NA	NA	NA	NA	1.01E-04	0.00E+00	NA	NA	NA	NA	NA	NA
16 Benzo(b)fluoranthene (S4UL)	100.0	0.0	0.0	100.0	1.48E+03	5.00E-03	NA	NA	NA	NA	1.28E-05	0.00E+00	NA	NA	NA	NA	NA	NA
17 Benzo(k)fluoranthene (S4UL)	100.0	0.0	0.0	100.0	4.64E+04	9.40E-02	NA	NA	NA	NA	3.38E-04	0.00E+00	NA	NA	NA	NA	NA	NA
18 Benzo(a)pyrene (S4UL)	100.0	0.0	0.0	100.0	1.29E+03	3.04E-03	NA	NA	NA	NA	1.01E-05	0.00E+00	NA	NA	NA	NA	NA	NA
19 Indeno(123-cd)pyrene (S4UL)	99.9	0.1	0.0	100.0	1.55E+04	6.31E-02	NA	NA	NA	NA	1.45E-04	0.00E+00	NA	NA	NA	NA	NA	NA
20 Dibenzo(ah)anthracene (S4UL)	100.0	0.0	0.0	100.0	1.60E+02	8.02E-04	NA	NA	NA	NA	1.01E-06	0.00E+00	NA	NA	NA	NA	NA	NA



		Soil Distribution				Media Concentrations													
		Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
		%	%	%	%	mg kg ⁻¹	mg m ⁻³	mg kg ⁻¹	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW
21	Benzene	57.3	39.9	2.8	100.0	7.96E+03	1.35E+06	NA	NA	NA	4.73E-02	0.00E+00	NA	NA	NA	NA	NA	NA	NA
22	Xylene, p-	89.9	9.5	0.6	100.0	6.99E+05	2.59E+07	NA	NA	NA	1.74E+00	0.00E+00	NA	NA	NA	NA	NA	NA	NA
23	Dibenzofuran	99.5	0.5	0.0	100.0	2.55E+05	4.16E+04	NA	NA	NA	3.38E-02	0.00E+00	NA	NA	NA	NA	NA	NA	NA
24	Carbazole	94.3	5.7	0.0	100.0	8.22E+04	1.98E+04	NA	NA	NA	1.69E-02	0.00E+00	NA	NA	NA	NA	NA	NA	NA
25	2-Methylnaphthalene	97.9	2.1	0.0	100.0	4.99E+05	2.33E+05	NA	NA	NA	1.33E-01	0.00E+00	NA	NA	NA	NA	NA	NA	NA
26	1,2,4-Trimethylbenzene	96.6	3.2	0.2	100.0	2.72E+04	2.74E+05	NA	NA	NA	3.38E-02	0.00E+00	NA	NA	NA	NA	NA	NA	NA
27	2,4-Dinitrotoluene	75.0	25.0	0.0	100.0	2.92E+05	9.82E+01	NA	NA	NA	6.76E-02	0.00E+00	NA	NA	NA	NA	NA	NA	NA
28	Chloromethane	11.2	76.3	12.5	100.0	5.74E+03	4.35E+06	NA	NA	NA	8.69E-02	0.00E+00	NA	NA	NA	NA	NA	NA	NA
29	Trichloroethene (S4UL)	73.0	24.3	2.8	100.0	3.45E+03	5.74E+05	NA	NA	NA	1.93E-02	0.00E+00	NA	NA	NA	NA	NA	NA	NA
30	2,4-Dimethylphenol	84.8	15.2	0.0	100.0	2.62E+06	5.19E+05	NA	NA	NA	6.76E-01	0.00E+00	NA	NA	NA	NA	NA	NA	NA

		Average Daily Exposure (mg kg ⁻¹ bw day ⁻¹)						Distribution by Pathway (%)								
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
1	Aliphatic EC >8-10 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.45E-01	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	0.00	50.00	0.00	50.00
2	Aromatic EC >8-10 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	0.00	50.00	0.00	50.00
3	Aromatic EC >10-12 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	0.00	50.00	0.00	50.00
4	Aromatic EC >12-16 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	5.62E+95	6.06E+95	0.00	0.00	0.00	0.00	0.00	50.00	0.00	50.00
5	Aromatic EC >16-21 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-02	5.62E+95	0.00E+00	0.00	0.00	0.00	0.00	0.00	50.00	50.00	0.00
6	Aromatic EC >21-35 (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-02	5.62E+95	0.00E+00	0.00	0.00	0.00	0.00	0.00	50.00	50.00	0.00
7	Naphthalene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.90E-04	3.94E-04	1.70E-04	0.00	0.00	0.00	0.00	0.00	80.26	0.00	19.74
8	Acenaphthylene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-02	7.88E-06	6.67E-07	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
9	Acenaphthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-02	5.51E-05	1.52E-06	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
10	Fluorene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-02	3.32E-05	5.82E-06	0.00	0.00	0.00	0.00	0.00	99.99	0.00	0.01
11	Phenanthrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02	8.66E-05	3.14E-05	0.00	0.00	0.00	0.00	0.00	99.75	0.00	0.25
12	Fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02	1.97E-05	5.09E-06	0.00	0.00	0.00	0.00	0.00	99.96	0.00	0.04
13	Pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-02	1.97E-05	3.94E-06	0.00	0.00	0.00	0.00	0.00	99.99	0.00	0.01
14	Benzo(a)anthracene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-06	3.38E-06	6.67E-07	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
15	Chrysene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-06	6.19E-06	1.03E-06	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
16	Benzo(b)fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E-07	6.19E-06	7.88E-07	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
17	Benzo(k)fluoranthene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-05	5.06E-06	4.24E-07	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
18	Benzo(a)pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-07	6.19E-06	3.64E-07	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
19	Indeno(123-cd)pyrene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.30E-06	5.63E-06	5.46E-07	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
20	Dibenzo(ah)anthracene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-08	2.25E-06	2.00E-06	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00



		Average Daily Exposure (mg kg ⁻¹ bw day ⁻¹)							Distribution by Pathway (%)							
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
21	Benzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
22	Xylene, p-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.15E-02	6.19E-04	8.49E-03	0.00	0.00	0.00	0.00	0.00	85.86	0.00	14.14
23	Dibenzofuran	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
24	Carbazole	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.00E-04	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
25	2-Methylnaphthalene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.94E-03	0.00E+00	6.06E-05	0.00	0.00	0.00	0.00	0.00	98.48	0.00	1.52
26	1,2,4-Trimethylbenzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-03	1.35E-03	5.21E-03	0.00	0.00	0.00	0.00	0.00	50.00	10.29	39.71
27	2,4-Dinitrotoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-03	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
28	Chloromethane	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-03	0.00E+00	1.29E-02	0.00	0.00	0.00	0.00	0.00	50.00	0.00	50.00
29	Trichloroethene (S4UL)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.70E-04	5.63E-04	1.21E-02	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
30	2,4-Dimethylphenol	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-02	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00



		Oral Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day ⁻¹)		Inhalation Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day ⁻¹)		Oral Mean Daily Intake ($\mu\text{g day}^{-1}$)		Inhalation Mean Daily Intake ($\mu\text{g day}^{-1}$)		Air-water partition coefficient (K_{ow}) ($\text{cm}^3 \text{cm}^{-3}$)		Coefficient of Diffusion in Air ($\text{m}^2 \text{s}^{-1}$)		Coefficient of Diffusion in Water ($\text{m}^2 \text{s}^{-1}$)		$\log K_{oc}$ ($\text{cm}^3 \text{g}^{-1}$)		$\log K_{ow}$ (dimensionless)		Dermal Absorption Fraction (dimensionless)		Soil-to-dust transport factor (g g^{-1} DW)		Sub-surface soil to indoor air correction factor (dimensionless)		Relative bioavailability via soil ingestion (unitless)		Relative bioavailability via dust inhalation (unitless)
1	Aliphatic EC >8-10 (S4UL)	TDI	100	TDI	290	9.99E+99		9.99E+99		4.15E+01		1.00E-05		1.00E-09		4.48		5.22		0.1		0.5		10		1		1
2	Aromatic EC >8-10 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		2.53E-01		1.00E-05		1.00E-09		3.2		3.69		0.1		0.5		10		1		1
3	Aromatic EC >10-12 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		7.22E-02		1.00E-05		1.00E-09		3.4		3.93		0.1		0.5		10		1		1
4	Aromatic EC >12-16 (S4UL)	TDI	40	TDI	60	9.99E+99		9.99E+99		1.26E-02		1.00E-05		1.00E-09		3.7		4.29		0.1		0.5		10		1		1
5	Aromatic EC >16-21 (S4UL)	TDI	30	NR	0	9.99E+99		0		6.95E-04		1.00E-05		1.00E-09		4.15		4.82		0.1		0.5		10		1		1
6	Aromatic EC >21-35 (S4UL)	TDI	30	NR	0	9.99E+99		0		2.48E-05		1.00E-05		1.00E-09		5.1		5.95		0.1		0.5		10		1		1
7	Naphthalene (S4UL)	TDI	20	TDI	0.86	7		2.8		6.62E-03		6.52E-06		5.16E-10		2.81		3.34		0.13		0.5		1		1		1
8	Acenaphthylene (S4UL)	TDI	60	TDI	60	0.14		0.011		5.68E-04		5.97E-06		4.82E-10		3.26		3.91		0.13		0.5		1		1		1
9	Acenaphthene (S4UL)	TDI	60	TDI	60	0.98		0.025		7.59E-04		5.85E-06		4.70E-10		3.37		4.03		0.13		0.5		1		1		1
10	Fluorene (S4UL)	TDI	40	TDI	40	0.59		0.096		4.12E-04		5.58E-06		4.47E-10		3.45		4.13		0.13		0.5		1		1		1
11	Phenanthrene (S4UL)	TDI	12.5	TDI	12.5	1.54		0.518		1.43E-04		5.34E-06		4.32E-10		3.74		4.5		0.13		0.5		1		1		1
12	Fluoranthene (S4UL)	TDI	12.5	TDI	12.5	0.35		0.084		6.29E-05		5.01E-06		4.11E-10		4.26		5.13		0.13		0.5		1		1		1
13	Pyrene (S4UL)	TDI	30	TDI	30	0.35		0.065		5.64E-05		5.01E-06		4.15E-10		4.21		5.08		0.13		0.5		1		1		1
14	Benzo(a)anthracene (S4UL)	ID	0.155	ID	0.0015	0.06		0.011		3.16E-05		4.60E-06		3.80E-10		4.89		5.91		0.13		0.5		1		1		1
15	Chrysene (S4UL)	ID	0.31	ID	0.003	0.11		0.017		3.18E-06		4.57E-06		3.77E-10		4.74		5.73		0.13		0.5		1		1		1
16	Benzo(b)fluoranthene (S4UL)	ID	0.039	ID	0.00038	0.11		0.013		2.05E-06		4.36E-06		3.62E-10		5.02		6.08		0.13		0.5		1		1		1
17	Benzo(k)fluoranthene (S4UL)	ID	1.03	ID	0.01	0.09		0.007		1.74E-06		4.36E-06		3.62E-10		5.17		6.26		0.13		0.5		1		1		1
18	Benzo(a)pyrene (S4UL)	ID	0.031	ID	0.0003	0.11		0.006		1.76E-06		4.38E-06		3.67E-10		5.11		6.18		0.13		0.5		1		1		1
19	Indeno(123-cd)pyrene (S4UL)	ID	0.443	ID	0.0043	0.1		0.009		2.05E-06		4.17E-06		3.51E-10		4.94		5.97		0.13		0.5		1		1		1
20	Dibenzo(ah)anthracene (S4UL)	ID	0.0031	ID	0.00003	0.04		0.033		5.40E-06		4.08E-06		3.40E-10		5.27		6.38		0.13		0.5		1		1		1



		Oral Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day^{-1})	Inhalation Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day^{-1})	Oral Mean Daily Intake ($\mu\text{g day}^{-1}$)	Inhalation Mean Daily Intake ($\mu\text{g day}^{-1}$)	Air-water partition coefficient (K_{aw}) ($\text{cm}^3 \text{cm}^{-3}$)	Coefficient of Diffusion in Air ($\text{m}^2 \text{s}^{-1}$)	Coefficient of Diffusion in Water ($\text{m}^2 \text{s}^{-1}$)	$\log K_{oc}$ ($\text{cm}^3 \text{g}^{-1}$)	$\log K_{ow}$ (dimensionless)	Dermal Absorption Fraction (dimensionless)	Soil-to-dust transport factor (g g^{-1} DW)	Sub-surface soil to indoor air correction factor (dimensionless)	Relative bioavailability via soil ingestion (unitless)	Relative bioavailability via dust inhalation (unitless)
21	Benzene	ID 0.29	ID 1.4	NR	NR	1.16E-01	8.77E-06	6.64E-10	1.83	2.13	0.1	0.5	10	1	1
22	Xylene, p-	TDI 180	TDI 60	11	140	1.07E-01	7.04E-06	5.31E-10	2.65	3.15	0.1	0.5	10	1	1
23	Dibenzofuran	TDI 1	NR 0	0	0	8.71E-03	4.10E-06	7.38E-10	3.962	4.12	0.03	0.5	1	1	1
24	Carbazole	ID 0.5	NR 0	NR	NR	1.15E-03	5.39E-06	4.40E-10	2.89	3.6	0.1	0.5	1	1	1
25	2-Methylnaphthalene	TDI 4	NR NR	0	1	6.06E-03	6.03E-06	4.75E-10	3.34	4	0.13	0.5	1	1	1
26	1,2,4-Trimethylbenzene	NR 0	TDI 2	24	86	8.56E-02	6.44E-06	4.87E-10	3.15	3.76	0.1	0.5	1	1	1
27	2,4-Dinitrotoluene	TDI 2	NR 0	0	0	3.67E-07	5.71E-06	4.66E-10	2.15	1.98	0.102	0.5	1	1	1
28	Chloromethane	NR 0	TDI 5.14	0	212	2.71E-01	1.28E-05	9.70E-10	0.84	0.91	0.1	0.5	1	1	1
29	Trichloroethene (S4UL)	ID 0.5	ID 0.57	10	200	1.87E-01	7.91E-06	6.23E-10	2.15	2.53	0.1	0.5	1	1	1
30	2,4-Dimethylphenol	TDI 20	NR 0	0	0	3.57E-04	6.56E-06	5.15E-10	2.42	2.35	0.1	0.5	1	1	1



		Soil-to-water partition coefficient (cm ³ g ⁻¹)	Vapour pressure (Pa)	Water solubility (mg L ⁻¹)	Soil-to-plant concentration factor for green vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for root vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tree fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)
1	Aliphatic EC >8-10 (S4UL)	1.75E+02	3.20E+02	4.27E-01	model	model	model	model	model	model
2	Aromatic EC >8-10 (S4UL)	9.19E+00	3.20E+02	6.46E+01	model	model	model	model	model	model
3	Aromatic EC >10-12 (S4UL)	1.46E+01	3.21E+01	2.45E+01	model	model	model	model	model	model
4	Aromatic EC >12-16 (S4UL)	2.91E+01	1.14E+00	5.75E+00	model	model	model	model	model	model
5	Aromatic EC >16-21 (S4UL)	8.19E+01	5.62E-03	6.53E-01	model	model	model	model	model	model
6	Aromatic EC >21-35 (S4UL)	7.30E+02	1.61E-06	6.61E-03	model	model	model	model	model	model
7	Naphthalene (S4UL)	3.74E+00	2.31E+00	1.90E+01	model	model	model	model	model	model
8	Acenaphthylene (S4UL)	1.06E+01	7.08E-02	7.95E+00	model	model	model	model	model	model
9	Acenaphthene (S4UL)	1.36E+01	7.37E-02	4.11E+00	model	model	model	model	model	model
10	Fluorene (S4UL)	1.63E+01	1.56E-02	1.86E+00	model	model	model	model	model	model
11	Phenanthrene (S4UL)	3.19E+01	2.82E-03	1.12E+00	model	model	model	model	model	model
12	Fluoranthene (S4UL)	1.06E+02	1.31E-04	2.30E-01	model	model	model	model	model	model
13	Pyrene (S4UL)	9.41E+01	1.53E-05	1.30E-01	model	model	model	model	model	model
14	Benzo(a)anthracene (S4UL)	4.50E+02	1.24E-06	3.80E-03	model	model	model	model	model	model
15	Chrysene (S4UL)	3.19E+02	4.52E-08	2.00E-03	model	model	model	model	model	model
16	Benzo(b)fluoranthene (S4UL)	6.07E+02	6.34E-08	2.00E-03	model	model	model	model	model	model
17	Benzo(k)fluoranthene (S4UL)	8.58E+02	1.64E-08	8.00E-04	model	model	model	model	model	model
18	Benzo(a)pyrene (S4UL)	7.47E+02	2.00E-08	3.80E-03	model	model	model	model	model	model
19	Indeno(123-cd)pyrene (S4UL)	5.05E+02	2.12E-09	2.00E-04	model	model	model	model	model	model
20	Dibenzo(ah)anthracene (S4UL)	1.08E+03	1.66E-10	6.00E-04	model	model	model	model	model	model



		Soil-to-water partition coefficient (cm ³ g ⁻¹)	Vapour pressure (Pa)	Water solubility (mg L ⁻¹)	Soil-to-plant concentration factor for green vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for root vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)	Soil-to-plant concentration factor for tree fruit (mg g ⁻¹ plant DW or FW basis over mg g ⁻¹ DW soil)
21	Benzene	3.92E-01	6.24E+03	1.78E+03	model	model	model	0.00E+00	0.00E+00	model
22	Xylene, p-	2.59E+00	4.75E+02	2.00E+02	model	model	model	0.00E+00	0.00E+00	model
23	Dibenzofuran	5.31E+01	3.31E-01	3.10E+00	model	model	model	model	model	model
24	Carbazole	4.50E+00	7.64E-06	1.16E+00	Model	Model	Model	Model	Model	Model
25	2-Methylnaphthalene	1.27E+01	3.41E+00	2.50E+01	model	model	model	model	model	model
26	1,2,4-Trimethylbenzene	8.19E+00	1.10E+02	5.59E+02	Model	Model	Model	Model	Model	Model
27	2,4-Dinitrotoluene	8.19E-01	1.54E-02	1.29E+02	Model	Model	Model	Model	Model	Model
28	Chloromethane	4.01E-02	3.31E+05	5.35E+03	Model	Model	Model	Model	Model	Model
29	Trichloroethene (S4UL)	8.19E-01	4.58E+03	1.37E+03	model	model	model	0.00E+00	0.00E+00	model
30	2,4-Dimethylphenol	1.53E+00	5.28E+00	8.11E+03	Model	Model	Model	Model	Model	Model

CLEA Software Version 1.071

Page 1 of 11

Report generated 08-Aug-22

Report title Outdoor Vapour Only GAC, Part 2

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RESULTS

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Appendix C
WMA Worked Example

Appendix C – Wilson Modular Approach Worked Example

The equations used in the Wilson Modular Approach (WMA) are detailed below in the worked example for naphthalene in the suspected combustion waste Made Ground together with justification for the input parameters. The equations are adopted from a paper entitled *Modular approach to analysing vapour migration into buildings in the UK* by Steve Wilson (Land Contamination & Reclamation, 16 (3), 2008). The WMA breaks down the equations to model migration of vapours from the source in the soil to indoor air into the following steps:

- Source vapour concentration in soil air;
- Modelling Flow from Ground to Sub-Floor Void;
- Dilution by Fresh Air in Void;
- Modelling Flow from Void to Building; and
- Modelling Dilution in the Building.

The equation references in each of the sections below have been kept the same as the numbering used in Wilson paper for consistency. The worksheets for each of the CoCs and for each of the material types identified at the site, included in Appendix D, also include a reference to the equation number for ease of reference.

Source Vapour Concentration in Soil Air

Equation (2), to calculate the source vapour concentration in soil air from soil contamination, is based on Henry's Law from the USEPA *User's Guide for evaluating Subsurface Vapor Intrusion into Buildings* (June 2003).

$$\text{Equation (2)} \quad C_{source} = \frac{H'_{TS} C_R \rho_b}{\theta_w + K_d \rho_b + H'_{TS} \theta_a}$$

Where:

- C_{source} = Vapour concentration at source (in g/cm³);
 C_R = Initial soil concentration (in g/g);
 ρ_b = Soil dry bulk density (in g/cm³);
 H'_{TS} = Henry's Law constant (dimensionless);
 θ_a = Soil air-filled porosity (in cm³/cm³);
 θ_w = Soil water-filled porosity (in cm³/cm³);
 K_d = Soil-water partition coefficient = $K_{oc} \times f_{oc}$ (in cm³/g);
 K_{oc} = Organic carbon-water partition coefficient (in cm³/g); and
 f_{oc} = Fraction of organic carbon in soil (dimensionless).

Table B1 indicates the values used for each of the parameters in equation (2) and the justification/source for the chosen value. The resultant calculated value for the source naphthalene vapour concentration in soil air from soil contamination (C_{source}) is also included in Table B1.

TABLE B1 - Summary of Parameters used to Calculate Naphthalene Vapour Concentration in Soil Air from Soil			
Parameter	Value	Units	Source
C_{source}	1.34×10^{-6}	g/cm ³	Calculated by equation (2)
C_R	1.31×10^{-2}	g/g	TP139, 2.4m concentration of 13,100mg/kg
ρ_b	1.18	g/cm ³	Value for sand in SR3
H'_{TS}	6.62×10^{-3}	dimensionless	K _{aw} value for naphthalene from SR7
θ_a	0.3	cm ³ /cm ³	Value for sand in SR3
θ_w	0.24	cm ³ /cm ³	Value for sand in SR3
K_d	64.6	cm ³ /g	Calculated from K _{oc} and f _{oc}
K_{oc}	646	cm ³ /g	Value for naphthalene from SR7
f_{oc}	0.1	dimensionless	Based on 95% Lower Confidence Limit SOM for Made Ground – Combustion Waste material type

The testing of water samples from the site generally indicated relatively low concentrations of potentially volatile contaminants. Comparison of groundwater quality data with SoBRA Groundwater Vapour Generic Assessment Criteria indicated that all concentrations were below the published assessment criteria with the exception of Aliphatic C10-C12 TPH in the sample collected from CP109 in 2020 (concentration of 117µg/l compared to a GAC of 37µg/l). Separate assessment discussed in the report has been done for this potential vapour CoC.

A check was also performed for each CoC to see if the potential contribution from groundwater could be significant. Equation (3), to calculate the source vapour concentration in soil air from groundwater contamination, is also based on Henry's Law from the USEPA *User's Guide for evaluating Subsurface Vapor Intrusion into Buildings* (June 2003). The maximum concentration for the CoC measured in groundwater at the site was used where it was found to be above the laboratory limit of detection.

$$\text{Equation (3)} \quad C_{source} = H'_{TS} C_w$$

Where:

C_{source} = Vapour concentration at source (in g/cm³);

H'_{TS} = Henry's Law constant (dimensionless); and

C_w = Initial groundwater concentration (in g/cm³).

Table B2 indicates the values used for each of the parameters in equation (3) and the justification/source for the chosen value. The resultant calculated value for the source naphthalene

vapour concentration in soil air from groundwater contamination (C_{source}) is also included in Table B2.

TABLE B2 - Summary of Parameters used to Calculate Naphthalene Vapour Concentration in Soil Air from Groundwater			
Parameter	Value	Units	Source
C_{source}	2.85×10^{-11}	g/cm ³	Calculated by equation (3)
C_w	4.3×10^{-9}	g/cm ³	TP139, 2.4m concentration of 13,100mg/kg
H'_{TS}	6.62×10^{-3}	dimensionless	K _{aw} value for naphthalene from SR7

While the concentration to the vapour concentration at source from groundwater is negligible compared to that from soil (it is five orders of magnitude lower), nevertheless it was added to the vapour contribution from soil in each case to ensure a conservative estimate of the vapour source was being modelled.

No measurable free product was identified on site which could be sampled and analysed in the laboratory, only sheens were noted in some areas. It has therefore not been possible to establish the nature of the sheen and / or incorporate potential contribution to the vapour modelling at this stage. Further comment on potential for vapour associated with free product are included in the main text.

Modelling Flow from Ground to Sub-Floor Void

Equation (5), to calculate diffusive flow from the source in the ground to the void, is based on Frick's Law from the USEPA *User's Guide for evaluating Subsurface Vapor Intrusion into Buildings* (June 2003). The use of diffusive flow in soil transport is supported by SR3, which does not recommend the use of advective flow models.

$$\text{Equation (5)} \quad E = \frac{A_B(C_{source} - C_{go})D_{eff}}{L}$$

Where:

- E = Rate of mass transfer by diffusion (in g/s);
- A_B = Cross-sectional area of floor slab / void (in cm²);
- C_{source} = Vapour concentration in soil (in g/cm³);
- C_{go} = Vapour concentration at top of soil / in void (in g/cm³);
- D_{eff} = Effective diffusion coefficient in soil (in cm²/s); and
- L = Length of migration pathway / depth to source in soil (in cm).

Equation (5a) is required to calculate the effective diffusion coefficient in soil, which is adapted from Equation 10.1 presented in SR3.

Equation (5a)
$$D_{eff} = D_{air} \frac{\theta_a^{3.33}}{\theta_T^2} + D_{water} \frac{\theta_w^{3.33}}{K_{aw}\theta_T^2}$$

Where:

- D_{eff} = Effective diffusion coefficient in soil (in cm²/s);
- D_{air} = Diffusion coefficient in air (in cm²/s);
- D_{water} = Diffusion coefficient in water (in cm²/s);
- θ_a = Soil air-filled porosity (in cm³/cm³);
- θ_w = Soil water-filled porosity (in cm³/cm³);
- θ_T = Soil total air and water-filled porosity (in cm³/cm³); and
- K_{aw} = air water partition coefficient (in cm³/cm³).

Table B3 indicates the values used for each of the parameters in equations (5) and (5a) along with the justification/source for the chosen value. The resultant calculated value for the rate of naphthalene mass transfer by diffusion (E) is also included in Table B3.

Table B3 - Summary of Parameters used to Calculate Rate of Naphthalene Mass Transfer by Diffusion			
Parameter	Value	Units	Source
E	2.55×10^{-5}	g/s	Calculated by equation (5)
A_B	2.80×10^5	cm ²	Small terrace footprint SR3
C_{source}	1.34×10^{-6}	g/cm ³	Calculated by equations (2) and (3)
C_{g0}	0	g/cm ³	Assumed fresh air in void
L	60	cm	Conservative assumption for depth below void to contamination used for all CoCs equivalent to thickness of clean cover required in gardens
D_{eff}	4.08×10^{-3}	cm ² /s	Calculated by equation (5a)
D_{air}	6.52×10^{-2}	cm ² /s	Value for naphthalene from SR7
D_{water}	5.16×10^{-6}	cm ² /s	Value for naphthalene from SR7
θ_a	0.30	cm ³ /cm ³	Value for sand in SR3
θ_w	0.24	cm ³ /cm ³	Value for sand in SR3
θ_T	0.54	cm ³ /cm ³	Value for sand in SR3
K_{aw}	6.62×10^{-3}	dimensionless	Value for naphthalene from SR7

Dilution by Fresh Air in Void

Equation (7), to calculate dilution by fresh air in the void, is based on equations presented in The CIEH *The Ground Gas Handbook* (Wilson et. al. 2008) and British Standard 5925:1991 *Code of practice for Ventilation principles and designing for natural ventilation*.

$$\text{Equation (7)} \quad C_{void} = \left(\frac{Q_{void}C_e + E}{Q_{void} + E} \right)$$

Where:

- C_{void} = Equilibrium concentration of the vapour in the void under steady state conditions (in g/cm³);
- Q_{void} = Flow rate of fresh air into void (in cm³/s);
- C_e = Concentration of vapour in outside air (in g/cm³); and
- E = Rate of mass transfer by diffusion (in g/s).

The flow rate of fresh air into the void can be calculated using a number of equations (7a – 7d) from British Standard 5925:1991 *Code of practice for Ventilation principles and designing for natural ventilation*. The design of the sub-floor void has been assumed to be 150mm in height with air bricks on two opposing walls in line with NHBC guidance (i.e. 1,500mm²/linear meter). For the purposes of these calculations, parameter choices for constants regarding wind flow have been chosen for the Manchester area in a conservative manner (e.g. exponent relating wind speed to height constant (α) and factor relating wind speed to height (K) were chosen for city terrain which is the most conservative).

Equations (7a - 7d) are included for completeness and to demonstrate the potential flow rate of fresh air in the void that would be expected as an average over time. However, to keep the model conservative, it has been run with an assumption of only 1 air exchange in the void per day.

Equation (7a) is used to determine the pressure coefficient difference (ΔC_p) or the difference in mean surface pressure coefficients on the two opposing foundation walls with air bricks.

$$\text{Equation (7a)} \quad \Delta C_p = A - B$$

Where:

- ΔC_p = Pressure Coefficient difference (dimensionless);
- A = The mean surface pressure coefficient for wall A (dimensionless); and
- B = The mean surface pressure coefficient for wall B which is opposite to wall A (dimensionless).

Both A and B are chosen from Table 13 in BS5925:1991 and are dependent on the void height and plan ratio. Values chosen for the purposes of this risk assessment yield the most conservative pressure coefficient difference and are based on a small terraced house plot at the site.

Equation (7b) is used to determine the reference wind speed corrected for height, terrain, area of the UK and proportion of time wind blowing.

$$\text{Equation (7b)} \quad \mu_r = \mu_{50} \xi K z^a$$

Where:

- μ_r = reference wind speed corrected for height (in m/s);
- μ_{50} = Wind speed at 10m exceeded 50% of the time (in m/s);
- ξ = Correction factor for percentage of time wind speed exceeded (dimensionless);
- K = Factor relating wind speed to height (dimensionless);
- z = Height of void (in m); and
- a = Exponent relating wind speed to height (dimensionless).

Equation (7c) is used to determine the equivalent area of openings in the air bricks.

$$\text{Equation (7c)} \quad \frac{1}{A_w^2} = \frac{1}{A_A^2} + \frac{1}{A_B^2}$$

Where:

- A_w = Equivalent area of openings in air bricks (in m²);
- A_A = Area of openings in air bricks on wall A (in m²); and
- A_B = Area of openings in air bricks on wall B (in m²).

Finally, equation (7d) is used to determine the ventilation rate of the sub-floor void.

$$\text{Equation (7d)} \quad Q_{void} = C_d A_w \mu_r \sqrt{\Delta C_p} * 1 \times 10^6 \left(\frac{cm^3}{m^3} \right)$$

Where:

- Q_{void} = Flow rate of fresh air into void (in cm³/s);
- C_d = Discharge coefficient for an opening (dimensionless)
- A_w = Equivalent area of openings in air bricks (in m²);
- μ_r = reference wind speed corrected for height (in m/s);
- ΔC_p = Pressure Coefficient difference (dimensionless);

Table B4 overleaf indicates the values used for each of the parameters in equations (7) through (7d) along with the justification/source for the chosen value. As mentioned above, parameters for equations (7a-7d) are included for comparative purposes as the flow of fresh air to the void has been

set equivalent to a conservative 1 exchange per day value. The resultant calculated value for the equilibrium concentration of naphthalene vapour in the void (C_{void}) is also included in Table B4.

Table B4- Summary of Parameters used to Calculate Equilibrium Concentration of Naphthalene in Void			
Parameter	Value	Units	Source
C_{void}	5.25×10^{-8}	g/cm ³	Calculated by equation (7)
Q_{void}	486	cm ³ /s	Equivalent to a conservative 1 air exchange per day (712 cm ³ /s calculated by equation (7d) equivalent to 8 exchanges per day)
C_e	0	g/cm ³	Assumed outdoor air
E	1.13×10^{-5}	g/s	Calculated by equation (5)
$\Delta C_{\bar{p}}$	0.8	dimensionless	Calculated by equation (7a)
A	0.7	dimensionless	Table 13 BS5925:1991 using worst case building dimension ratio
B	-0.1	dimensionless	Table 13 BS5925:1991 using worst case building dimension ratio
μ_r	0.23	m/s	Calculated by equation (7b)
μ_{50}	4.5	m/s	Manchester data (Fig 5 BS5925:1991)
ξ	0.46	dimensionless	Table 9 BS5925:1991 (sheltered inland exceeded 80% of time)
K	0.21	dimensionless	Table 8 BS5925:1991 (worst case city terrain assumed)
z	0.15	m	Assumed void height
a	0.33	dimensionless	Table 8 BS5925:1991 (worst case city terrain assumed)
A_w	5.6×10^{-3}	m ²	Calculated by equation (7c)
A_A	7.9×10^{-3}	m ²	Based on square small terraced plot and air bricks in accordance with NHBC guidance on end walls
A_B	7.9×10^{-3}	m ²	Based on square small terraced plot and air bricks in accordance with NHBC guidance on end walls
C_d	0.61	dimensionless	Recommended value in BS5925:1991

Modelling Flow from Void to Building

Equation (9), to calculate advective flow from the void through the slab to the building, is based on Darcy's Law. This is the same transport that is used within the Johnson and Ettinger approach and does not include allowance for a vapour barrier (or any kind of barrier which would significantly restrict air flow from the void to the indoor space). If a properly designed vapour barrier is incorporated into the foundation design, flow through the slab/barrier will be by diffusive flow and is calculated using an effective diffusion coefficient for the whole of the slab.

Equation (9)
$$Q_{entry} = \frac{\Delta P k_v A_{crack}}{\mu D_{crack}} C_{void}$$

Where:

- Q_{entry} = Volumetric inflow of vapour to building (in g/s);
 ΔP = Pressure difference between inside of building and void (in Pa);
 k_v = Floor slab (crack) permeability to vapour flow (intrinsic permeability) (in cm²);
 A_{crack} = Area of cracks in floor slab (in cm²);
 μ = Viscosity of air (in Pa.s);
 D_{crack} = Thickness of floor slab (cm); and
 C_{void} = Equilibrium concentration of the vapour in the void under steady state conditions (in g/cm³).

Table B5 indicates the values used for each of the parameters in equations (9) along with the justification/source for the chosen value. The resultant calculated value for the volumetric inflow of naphthalene vapour to the building (Q_{entry}) is also included in Table B5.

Table B5 - Summary of Parameters used to Calculate Volumetric Inflow of Naphthalene Vapour to Building			
Parameter	Value	Units	Source
Q_{entry}	5.10×10^{-8}	g/s	Calculated by equation (9)
ΔP	3.1	Pa	Small terrace pressure difference SR3
k_v	2×10^{-7}	cm ²	Value from Wilson 2008
A_{crack}	423.3	cm ²	Small terrace crack area SR3
μ	1.8×10^{-5}	Pa s	SR3 Appendix 1
D_{crack}	15	cm	Small terrace slab thickness SR3
C_{void}	5.25×10^{-8}	g/cm ³	Calculated by equation (7)

Modelling Dilution in the Building

Equation (10), to calculate dilution by fresh air in the indoor space / building, is based on equations presented in The CIEH *The Ground Gas Handbook* (Wilson et. al. 2008) and British Standard 5925:1991 *Code of practice for Ventilation principles and designing for natural ventilation*. A simplified version of this equation is used within the Johnson and Ettinger approach.

$$\text{Equation (10)} \quad C_{building} = \left(\frac{Q_{building} C_e + Q_{entry}}{Q_{building} + Q_{entry}} \right)$$

Where:

- $C_{building}$ = Equilibrium concentration of the vapour in the building under steady state conditions (in g/cm³);
 $Q_{building}$ = Flow rate of fresh air into building (in cm³/s);
 C_e = Concentration of vapour in outside air (in g/cm³); and
 Q_{entry} = Volumetric inflow of vapour to building (in g/s).

Table B6 indicates the values used for each of the parameters in equations (10) along with the justification/source for the chosen value. The resultant calculated value for the equilibrium concentration of naphthalene vapour in the building under steady state conditions ($C_{building}$) is also included in Table B6.

Table B6 - Summary of Parameters used to Calculate Equilibrium Naphthalene Vapour Concentration in Building			
Parameter	Value	Units	Source
$C_{building}$	2.73×10^{-12}	g/cm^3	Calculated by equation (10)
$Q_{building}$	1.87×10^4	cm^3/s	Based on small terrace parameters in SR3
C_e	0	g/cm^3	Assumed concentration in outdoor air
Q_{entry}	5.10×10^{-8}	g/s	Calculated by equation (9)

Therefore, the indoor equilibrium concentration of naphthalene ($C_{building}$) is calculated to be $2.73\mu g/m^3$ ($2.73 \times 10^{-12}g/cm^3$) with only a ventilated sub-floor void accounted for in the model which is below the naphthalene Tolerable Daily Soil Intake (TDSI) for a six-year-old child of $2.87\mu g/m^3$ ($0.82\mu g\ kg^{-1}\ bw\ day^{-1}$).

These modelling results are discussed in the context of the understanding of the CSM and sensitivity analysis undertaken in the main text. Modelling worksheets for all of the CoCs, including naphthalene are included for reference in Appendix D. The applicable inhalation health criterion value for each of the CoC is included on the relevant worksheet for reference.

Appendix D
WMA Worksheets

		Contaminant: dibenzofuran			Building Type: Small Terrace												
		HCV _{inh} (ID or TDSI):			1	=	3.5	Soil Type: Sand									
					µg/kg-d			µg/m³									
		Calculated Indoor Vapour Concentration from Equation 10 below for comparison with HCV _{inh}			C _{building}	1.23E-03	µg/m³										
Wilson eq					Input Parameters		units	Calculated Variables		units	Outputs		units				
Source Vapour Concentration in Soil Air from Soil Contamination																	
(2)	Soil Concentration	C _R	20	mg/kg	C _R	0.00002	g/g										
	Soil dry bulk density	ρ _b	1.18	g/cm³													
	Dimensionless Henry's Law constant (or K _{ow})	H _{TS}	0.00071	-													
	Soil air filled porosity	θ _a	0.3	cm³/cm³													
	Soil water filled porosity	θ _w	0.24	cm³/cm³	θ _t	0.54	cm³/cm³										
	Octanol-water partition coefficient	K _{oc}	3388.4416	cm³/g													
	Soil fraction organic carbon	f _{oc}	0.0064	-	K _d	21.686026	cm³/g	C _{source}	6.49E-10	g/cm³	6.49E-01	µg/m³					
Source Vapour Concentration in Soil Air from Groundwater Contamination																	
(3)	Groundwater concentration	C _w		µg/l	C _w	0.00E+00	g/cm³									equivalent soil concentration	
	Dimensionless Henry's Law constant (or K _{ow})	H _{TS}	0.00071	-				C _{source}	0.00E+00	g/cm³	0.00	mg/kg					
Source Vapour Concentration in Soil Air from NAPL																	
(4)	NAPL Mole fraction	X _i		-													
	Vapour Pressure	P _o	7.599E-08	atm													
	Moelcular Weight	MW	168.19	g/mol													
	Universal Gas Constant	R	8.21E-05	m³atm/molK													
	Soil Temperature	T	283.15	K				C _{source}	0.00E+00	g/cm³							
Combined Vapour Concentration from Soil, Groundwater and / or NAPL																	
	Sum of C _{source} calculated individually for soil, groundwater and NAPL.							C _{source}	6.49E-10	g/cm³							
Diffusive Flow from Ground to Void																	
(5)	Floor Area	A _b	2.80E+05	cm²													
	Soil (S), Water (W), NAPL (N) or (C) combined	Source Type	S	-													
	Vapour concentration at top of soil	C _{so}	0.00E+00	g/cm³													
	Diffusion coefficient in air	D _{air}	5.76E-02	cm²/s													
	Diffusion coefficient in water	D _{water}	4.65E-06	cm²/s	D _{eff}	3.78E-03	cm²/s										
	Depth to Source	L	60	cm				E	1.14E-08	g/s							
Concentration in Void after Dilution by Fresh Air in Void																	
(7)	Air Exchanges in Void	V _{ex}	1	1/day	T _{exchange}	86400	s										
	Void Height	H _{void}	150	cm	Q _{void}	486.11	cm³/s										
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³													
	Use Air exchange/day (1) or BS5925 (2)	1 or 2	1	-				C _{void}	2.35E-11	g/cm³							
Advective Flow from Void (Ground) Through Cracks into Building																	
(9)	Pressure difference	ΔP	3.1	Pa													
	Intrinsic permeability of floor slab	k _v	2.00E-07	cm²													
	Area of cracks in floor salb	A _{crack}	423.3	cm²													
	Viscosity of air	μ	1.80E-05	Pa s													
	thickness of floor salb	D _{crack}	15	cm				Q _{entry}	2.29E-11	g/s							
Diffusive Flow from Void through slab/barrier into building																	
	Floor Area	A _b	2.80E+05	cm²													
	Vapour concentration in building	C _{so}		g/cm³													
	Effective Diffusion coefficient for whole slab (barrie	D _{eff}		cm²/s													
	Slab/barrier thickness	L		cm				Q _{entry}	#DIV/0!	g/s							
Concentration in Building after Dilution by Fresh Air in Void (Advective flow - no Barrier)																	
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr													
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³													
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	1.225E-15	g/cm³							
									1.23E-03	µg/m³							
Concentration in Building after Dilution by Fresh Air in Void (Diffusive Flow - Vapour Barrier)																	
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr													
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	#DIV/0!	g/cm³							
									#DIV/0!	µg/m³							

Contaminant: Benz[a]anthracene				Building Type: Small Terrace												
HCV _{inh} (ID or TDSI):				0.0015	=	0.00525	Soil Type: Sand									
				µg/kg-d		µg/m³										
Calculated Indoor Vapour Concentration from Equation 10 below for comparison with HCV _{inh}				C _{building}	1.97E-05	µg/m³										
Wilson eq	Input Parameters				units	Calculated Variables		units	Outputs		units					
Source Vapour Concentration in Soil Air from Soil Contamination																
(2)	Soil Concentration	C _R	432	mg/kg	C _R	0.000432	g/g									
	Soil dry bulk density	ρ _b	1.18	g/cm³												
	Dimensionless Henry's Law constant (or K _{ow})	H _{TS}	0.0000316	-												
	Soil air filled porosity	Θ _a	0.3	cm³/cm³												
	Soil water filled porosity	Θ _w	0.24	cm³/cm³	Θ _r	0.54	cm³/cm³									
	Octanol-water partition coefficient	K _{oc}	77624.712	cm³/g												
	Soil fraction organic carbon	f _{sc}	0.032	-	K _d	2483.9908	cm³/g	C _{source}	5.50E-12	g/cm³	5.50E-03	µg/m³				
Source Vapour Concentration in Soil Air from Groundwater Contamination																
(3)	Groundwater concentration	C _w	19.9	µg/l	C _w	1.99E-08	g/cm³							equivalent soil concentration		
	Dimensionless Henry's Law constant (or K _{ow})	H _{TS}	0.0000316	-					C _{source}	6.29E-13	g/cm³	49.44	mg/kg			
Source Vapour Concentration in Soil Air from NAPL																
(4)	NAPL Mole fraction	X _i	-	-												
	Vapour Pressure	P _o	1.224E-11	atm												
	Moelcular Weight	MW	228.29	g/mol												
	Universal Gas Constant	R	8.21E-05	m³atm/molK												
	Soil Temperature	T	283.15	K					C _{source}	0.00E+00	g/cm³					
Combined Vapour Concentration from Soil, Groundwater and / or NAPL																
	Sum of C _{source} calculated individually for soil, groundwater and NAPL.								C _{source}	6.12E-12	g/cm³					
Diffusive Flow from Ground to Void																
(5)	Floor Area	A _b	2.80E+05	cm²												
	Soil (S), Water (W), NAPL (N) or (C) combined	Source Type	c	-												
	Vapour concentration at top of soil	C _{so}	0.00E+00	g/cm³												
	Diffusion coefficient in air	D _{air}	4.60E-02	cm²/s												
	Diffusion coefficient in water	D _{water}	3.80E-06	cm²/s	D _{eff}	6.42E-03	cm²/s									
	Depth to Source	L	60	cm					E	1.84E-10	g/s					
Concentration in Void after Dilution by Fresh Air in Void																
(7)	Air Exchanges in Void	V _{ex}	1	1/day	T _{exchange}	86400	s									
	Void Height	H _{void}	150	cm	Q _{void}	486.11	cm³/s									
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³												
	Use Air exchange/day (1) or BS5925 (2)	1 or 2	1	-					C _{void}	3.78E-13	g/cm³					
Advective Flow from Void (Ground) Through Cracks into Building																
(9)	Pressure difference	ΔP	3.1	Pa												
	Intrinsic permeability of floor slab	k _v	2.00E-07	cm²												
	Area of cracks in floor salb	A _{crack}	423.3	cm²												
	Viscosity of air	μ	1.80E-05	Pa s												
	thickness of floor salb	D _{crack}	15	cm					Q _{entry}	3.67E-13	g/s					
Diffusive Flow from Void through slab/barrier into building																
	Floor Area	A _b	2.80E+05	cm²												
	Vapour concentration in building	C _{so}		g/cm³												
	Effective Diffusion coefficient for whole slab (barrie	D _{eff}		cm²/s												
	Slab/barrier thickness	L		cm					Q _{entry}	#DIV/0!	g/s					
Concentration in Building after Dilution by Fresh Air in Void (Advective flow - no Barrier)																
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr												
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³												
	Building height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	1.966E-17	g/cm³						
										1.97E-05	µg/m³					
Concentration in Building after Dilution by Fresh Air in Void (Diffusive Flow - Vapour Barrier)																
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr												
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	#DIV/0!	g/cm³						
										#DIV/0!	µg/m³					

Contaminant: Dibenz[ah]anthracene				Building Type: Small Terrace													
HCV _{inh} (ID or TDSI):				0.00003	=	0.000105	Soil Type: Sand										
				µg/kg-d		µg/m³											
Calculated Indoor Vapour Concentration from Equation 10 below for comparison with HCV _{inh}				C _{building}	7.71E-07	µg/m³											
Wilson eq	Input Parameters			units		Calculated Variables		units		Outputs		units					
Source Vapour Concentration in Soil Air from Soil Contamination																	
(2)	Soil Concentration	C _R	51.6	mg/kg	C _R	0.0000516	g/g										
	Soil dry bulk density	ρ _b	1.18	g/cm³													
	Dimensionless Henry's Law constant (or K _{ow})	H _{TS}	0.0000054	-													
	Soil air filled porosity	Θ _a	0.3	cm³/cm³													
	Soil water filled porosity	Θ _w	0.24	cm³/cm³	Θ _t	0.54	cm³/cm³										
	Octanol-water partition coefficient	K _{oc}	186208.71	cm³/g													
	Soil fraction organic carbon	f _{oc}	0.032	-	K _d	5958.6788	cm³/g	C _{source}	4.68E-14	g/cm³	4.68E-05	µg/m³					
Source Vapour Concentration in Soil Air from Groundwater Contamination																	
(3)	Groundwater concentration	C _w	4.83	µg/l	C _w	4.83E-09	g/cm³							equivalent soil concentration			
	Dimensionless Henry's Law constant (or K _{ow})	H _{TS}	0.0000054	-					C _{source}	2.61E-14	g/cm³	28.78	mg/kg				
Source Vapour Concentration in Soil Air from NAPL																	
(4)	NAPL Mole fraction	X _i	-	-													
	Vapour Pressure	P _o	1.638E-15	atm													
	Moelcular Weight	MW	278.35	g/mol													
	Universal Gas Constant	R	8.21E-05	m³atm/molK													
	Soil Temperature	T	283.15	K					C _{source}	0.00E+00	g/cm³						
Combined Vapour Concentration from Soil, Groundwater and / or NAPL																	
	Sum of C _{source} calculated individually for soil, groundwater and NAPL.									C _{source}	7.28E-14	g/cm³					
Diffusive Flow from Ground to Void																	
(5)	Floor Area	A _b	2.80E+05	cm²													
	Soil (S), Water (W), NAPL (N) or (C) combined	Source Type	c	-													
	Vapour concentration at top of soil	C _{so}	0.00E+00	g/cm³													
	Diffusion coefficient in air	D _{air}	4.08E-02	cm²/s													
	Diffusion coefficient in water	D _{water}	3.40E-06	cm²/s	D _{eff}	2.12E-02	cm²/s										
	Depth to Source	L	60	cm					E	7.20E-12	g/s						
Concentration in Void after Dilution by Fresh Air in Void																	
(7)	Air Exchanges in Void	V _{ex}	1	1/day	T _{exchange}	86400	s										
	Void Height	H _{void}	150	cm	Q _{void}	486.11	cm³/s										
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³													
	Use Air exchange/day (1) or BS5925 (2)	1 or 2	1	-					C _{void}	1.48E-14	g/cm³						
Advective Flow from Void (Ground) Through Cracks into Building																	
(9)	Pressure difference	ΔP	3.1	Pa													
	Intrinsic permeability of floor slab	k _v	2.00E-07	cm²													
	Area of cracks in floor salb	A _{crack}	423.3	cm²													
	Viscosity of air	μ	1.80E-05	Pa s													
	thickness of floor salb	D _{crack}	15	cm					Q _{entry}	1.44E-14	g/s						
Diffusive Flow from Void through slab/barrier into building																	
	Floor Area	A _b	2.80E+05	cm²													
	Vapour concentration in building	C _{so}		g/cm³													
	Effective Diffusion coefficient for whole slab (barrier)	D _{eff}		cm²/s													
	Slab/barrier thickness	L		cm					Q _{entry}	#DIV/0!	g/s						
Concentration in Building after Dilution by Fresh Air in Void (Advective flow - no Barrier)																	
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr													
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³													
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	7.711E-19	g/cm³	7.71E-07	µg/m³					
Concentration in Building after Dilution by Fresh Air in Void (Diffusive Flow - Vapour Barrier)																	
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr													
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	#DIV/0!	g/cm³	#DIV/0!	µg/m³					

		Contaminant: Aliphatic EC >8-10				Building Type: Small Terrace												
		HCV _{inh} (ID or TDSI):	145	=	507.5		Soil Type: Sand											
			µg/kg-d		µg/m³													
		Calculated Indoor Vapour Concentration from Equation 10 below for comparison with HCV _{inh}	C _{building}	3.32E+01	µg/m³													
Wilson eq		Input Parameters			units	Calculated Variables			units	Outputs			units					
Source Vapour Concentration in Soil Air from Soil Contamination																		
(2)	Soil Concentration	C _R	703	mg/kg	C _R	0.000703	g/g											
	Soil dry bulk density	ρ _b	1.18	g/cm³														
	Dimensionless Henry's Law constant (or K _{ow})	H' _{TS}	41.5	-														
	Soil air filled porosity	Θ _a	0.3	cm³/cm³														
	Soil water filled porosity	Θ _w	0.24	cm³/cm³	Θ _t	0.54	cm³/cm³											
	Octanol-water partition coefficient	K _{oc}	30199.517	cm³/g														
	Soil fraction organic carbon	f _{oc}	0.1	-	K _d	3019.9517	cm³/g	C _{source}	9.63E-06	g/cm³	9.63E+03	µg/m³						
Source Vapour Concentration in Soil Air from Groundwater Contamination																		
(3)	Groundwater concentration	C _w	25	µg/l	C _w	2.50E-08	g/cm³											
	Dimensionless Henry's Law constant (or K _{ow})	H' _{TS}	41.5	-				C _{source}	1.04E-06	g/cm³								equivalent soil concentration 75.77 mg/kg
Source Vapour Concentration in Soil Air from NAPL																		
(4)	NAPL Mole fraction	X _i	-	-														
	Vapour Pressure	P _o	0.0031582	atm														
	Moelcular Weight	MW	130	g/mol														
	Universal Gas Constant	R	8.21E-05	m³atm/molK														
	Soil Temperature	T	283.15	K				C _{source}	0.00E+00	g/cm³								
Combined Vapour Concentration from Soil, Groundwater and / or NAPL																		
	Sum of C _{source} calculated individually for soil, groundwater and NAPL.							C _{source}	1.07E-05	g/cm³								
Diffusive Flow from Ground to Void																		
(5)	Floor Area	A _b	2.80E+05	cm²														
	Soil (S), Water (W), NAPL (N) or (C) combined	Source Type	c	-														
	Vapour concentration at top of soil	C _{so}	0.00E+00	g/cm³														
	Diffusion coefficient in air	D _{air}	1.00E-01	cm²/s														
	Diffusion coefficient in water	D _{water}	1.00E-05	cm²/s	D _{eff}	6.22E-03	cm²/s											
	Depth to Source	L	60	cm				E	3.10E-04	g/s								
Concentration in Void after Dilution by Fresh Air in Void																		
(7)	Air Exchanges in Void	V _{ex}	1	1/day	T _{exchange}	86400	s											
	Void Height	H _{void}	150	cm	Q _{void}	486.11	cm³/s											
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³														
	Use Air exchange/day (1) or BS5925 (2)	1 or 2	1	-				C _{void}	6.37E-07	g/cm³								
Advective Flow from Void (Ground) Through Cracks into Building																		
(9)	Pressure difference	ΔP	3.1	Pa														
	Intrinsic permeability of floor slab	k _v	2.00E-07	cm²														
	Area of cracks in floor salb	A _{crack}	423.3	cm²														
	Viscosity of air	μ	1.80E-05	Pa s														
	thickness of floor salb	D _{crack}	15	cm				Q _{entry}	6.19E-07	g/s								
Diffusive Flow from Void through slab/barrier into building																		
	Floor Area	A _b	2.80E+05	cm²														
	Vapour concentration in building	C _{so}		g/cm³														
	Effective Diffusion coefficient for whole slab (barrie	D _{eff}		cm²/s														
	Slab/barrier thickness	L		cm				Q _{entry}	#DIV/0!	g/s								
Concentration in Building after Dilution by Fresh Air in Void (Advective flow - no Barrier)																		
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr														
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³														
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	3.318E-11	g/cm³								
									3.32E+01	µg/m³								
Concentration in Building after Dilution by Fresh Air in Void (Diffusive Flow - Vapour Barrier)																		
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr														
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	#DIV/0!	g/cm³								
									#DIV/0!	µg/m³								

		Contaminant: Benz[a]anthracene			Building Type: Small Terrace													
		HCV _{inh} (ID or TDSI):	0.0015	=	0.00525	Soil Type:		Sand										
			µg/kg-d		µg/m ³													
		Calculated Indoor Vapour Concentration from Equation 10 below for comparison with HCV _{inh}	C _{building}	1.60E-05	µg/m ³													
Wilson eq		Input Parameters			units	Calculated Variables		units	Outputs		units							
Source Vapour Concentration in Soil Air from Soil Contamination																		
(2)	Soil Concentration	C _R	311	mg/kg	C _R	0.000311	g/g											
	Soil dry bulk density	ρ _b	1.18	g/cm ³														
	Dimensionless Henry's Law constant (or K _{ow})	H [*] _{TS}	0.0000316	-														
	Soil air filled porosity	Θ _a	0.3	cm ³ /cm ³														
	Soil water filled porosity	Θ _w	0.24	cm ³ /cm ³	Θ _T	0.54	cm ³ /cm ³											
	Octanol-water partition coefficient	K _{oc}	77624.712	cm ³ /g														
	Soil fraction organic carbon	f _{oc}	0.029	-	K _d	2251.1166	cm ³ /g	C _{source}	4.37E-12	g/cm ³	4.37E-03	µg/m ³						
Source Vapour Concentration in Soil Air from Groundwater Contamination																		
(3)	Groundwater concentration	C _w	19.9	µg/l	C _w	1.99E-08	g/cm ³											
	Dimensionless Henry's Law constant (or K _{ow})	H [*] _{TS}	0.0000316	-					C _{source}	6.29E-13	g/cm ³					equivalent soil concentration 44.80 mg/kg		
Source Vapour Concentration in Soil Air from NAPL																		
(4)	NAPL Mole fraction	X _i	-	-														
	Vapour Pressure	P _v	1.224E-11	atm														
	Moelcular Weight	MW	228.29	g/mol														
	Universal Gas Constant	R	8.21E-05	m ³ atm/molK														
	Soil Temperature	T	283.15	K					C _{source}	0.00E+00	g/cm ³							
Combined Vapour Concentration from Soil, Groundwater and / or NAPL																		
	Sum of C _{source} calculated individually for soil, groundwater and NAPL.								C _{source}	4.99E-12	g/cm ³							
Diffusive Flow from Ground to Void																		
(5)	Floor Area	A _{fb}	2.80E+05	cm ²														
	Soil (S), Water (W), NAPL (N) or (C) combined	Source Type	C	-														
	Vapour concentration at top of soil	C _{gs}	0.00E+00	g/cm ³														
	Diffusion coefficient in air	D _{air}	4.60E-02	cm ² /s														
	Diffusion coefficient in water	D _{water}	3.80E-06	cm ² /s	D _{eff}	6.42E-03	cm ² /s											
	Depth to Source	L	60	cm					E	1.50E-10	g/s							
Concentration in Void after Dilution by Fresh Air in Void																		
(7)	Air Exchanges in Void	V _{ex}	1	1/day	T _{exchange}	86400	s											
	Void Height	H _{void}	150	cm	Q _{void}	486.11	cm ³ /s											
	Vapour concentration in outdoor air	C _a	0.00E+00	g/cm ³														
	Use Air exchange/day (1) or BS5925 (2)	1 or 2	1	-					C _{void}	3.08E-13	g/cm ³							
Advective Flow from Void (Ground) Through Cracks into Building																		
(9)	Pressure difference	ΔP	3.1	Pa														
	Intrinsic permeability of floor slab	k _v	2.00E-07	cm ²														
	Area of cracks in floor salb	A _{crack}	423.3	cm ²														
	Viscosity of air	μ	1.80E-05	Pa s														
	thickness of floor salb	D _{crack}	15	cm					Q _{entry}	2.99E-13	g/s							
Diffusive Flow from Void through slab/barrier into building																		
	Floor Area	A _b	2.80E+05	cm ²														
	Vapour concentration in building	C _{gb}		g/cm ³														
	Effective Diffusion coefficient for whole slab (barrie	D _{eff}		cm ² /s														
	Slab/barrier thickness	L		cm					Q _{entry}	#DIV/0!	g/s							
Concentration in Building after Dilution by Fresh Air in Void (Advective flow - no Barrier)																		
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr														
	Vapour concentration in outdoor air	C _a	0.00E+00	g/cm ³														
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm ³ /s	C _{building}	1.603E-17	g/cm ³	1.60E-05	µg/m ³						
Concentration in Building after Dilution by Fresh Air in Void (Diffusive Flow - Vapour Barrier)																		
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr														
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm ³ /s	C _{building}	#DIV/0!	g/cm ³	#DIV/0!	µg/m ³						

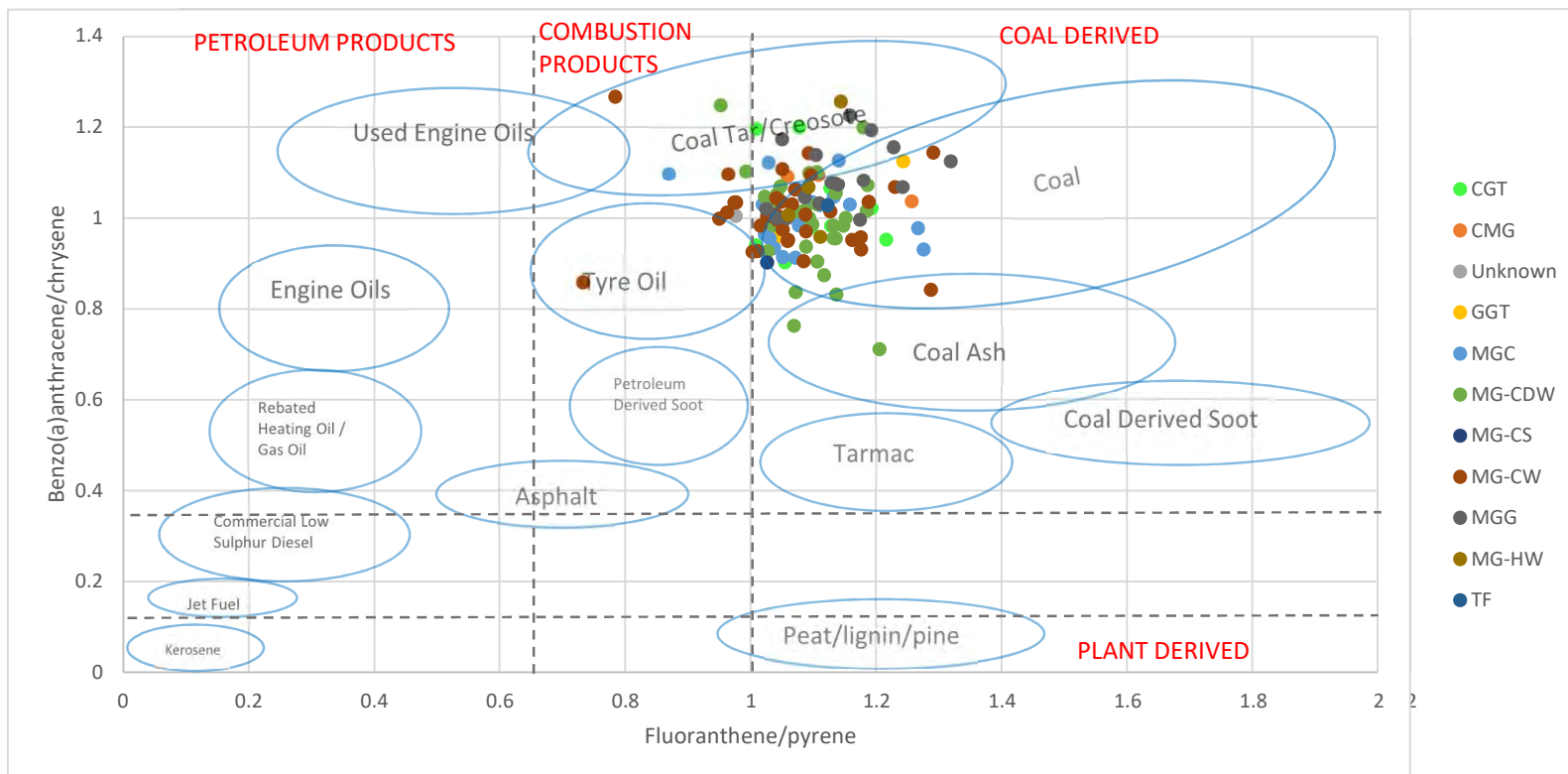
		Contaminant: Carbazole			Building Type: Small Terrace														
		HCV _{inh} (ID or TDSI):			5	=	17.5	Soil Type: Sand											
				µg/kg-d			µg/m³												
		Calculated Indoor Vapour Concentration from Equation 10 below for comparison with HCV _{inh}			C _{building}	6.14E-03	µg/m³												
Wilson eq		Input Parameters			units			Calculated Variables			units			Outputs			units		
Source Vapour Concentration in Soil Air from Soil Contamination																			
(2)	Soil Concentration	C _R	70	mg/kg	C _R	0.00007	g/g												
	Soil dry bulk density	ρ _b	1.18	g/cm³															
	Dimensionless Henry's Law constant (or K _{ow})	H _{TS}	0.00115	-															
	Soil air filled porosity	Θ _a	0.3	cm³/cm³															
	Soil water filled porosity	Θ _w	0.24	cm³/cm³	Θ _t	0.54	cm³/cm³												
	Octanol-water partition coefficient	K _{oc}	776.24712	cm³/g															
	Soil fraction organic carbon	f _{oc}	0.029	-	K _d	22.511166	cm³/g	C _{source}	3.54E-09	g/cm³	3.54E+00	µg/m³							
Source Vapour Concentration in Soil Air from Groundwater Contamination																			
(3)	Groundwater concentration	C _w		µg/l	C _w	0.00E+00	g/cm³												
	Dimensionless Henry's Law constant (or K _{ow})	H _{TS}	0.00115	-				C _{source}	0.00E+00	g/cm³						equivalent soil concentration			
																0.00 mg/kg			
Source Vapour Concentration in Soil Air from NAPL																			
(4)	NAPL Mole fraction	X _i		-															
	Vapour Pressure	P _o	7.54E-11	atm															
	Moelcular Weight	MW	167.21	g/mol															
	Universal Gas Constant	R	8.21E-05	m³atm/molK															
	Soil Temperature	T	283.15	K				C _{source}	0.00E+00	g/cm³									
Combined Vapour Concentration from Soil, Groundwater and / or NAPL																			
	Sum of C _{source} calculated individually for soil, groundwater and NAPL.							C _{source}	3.54E-09	g/cm³									
Diffusive Flow from Ground to Void																			
(5)	Floor Area	A _b	2.80E+05	cm²															
	Soil (S), Water (W), NAPL (N) or (C) combined	Source Type	S	-															
	Vapour concentration at top of soil	C _{so}	0.00E+00	g/cm³															
	Diffusion coefficient in air	D _{air}	5.39E-02	cm²/s															
	Diffusion coefficient in water	D _{water}	4.40E-06	cm²/s	D _{eff}	3.47E-03	cm²/s												
	Depth to Source	L	60	cm				E	5.73E-08	g/s									
Concentration in Void after Dilution by Fresh Air in Void																			
(7)	Air Exchanges in Void	V _{ex}	1	1/day	T _{exchange}	86400	s												
	Void Height	H _{void}	150	cm	Q _{void}	486.11	cm³/s												
	Vapour concentration in outdoor air	C _o	0.00E+00	g/cm³															
	Use Air exchange/day (1) or BS5925 (2)	1 or 2	1	-				C _{void}	1.18E-10	g/cm³									
Advective Flow from Void (Ground) Through Cracks into Building																			
(9)	Pressure difference	ΔP	3.1	Pa															
	Intrinsic permeability of floor slab	k _v	2.00E-07	cm²															
	Area of cracks in floor salb	A _{crack}	423.3	cm²															
	Viscosity of air	μ	1.80E-05	Pa s															
	thickness of floor salb	D _{crack}	15	cm				Q _{entry}	1.15E-10	g/s									
Diffusive Flow from Void through slab/barrier into building																			
	Floor Area	A _b	2.80E+05	cm²															
	Vapour concentration in building	C _{so}		g/cm³															
	Effective Diffusion coefficient for whole slab (barrie	D _{eff}		cm²/s															
	Slab/barrier thickness	L		cm				Q _{entry}	#DIV/0!	g/s									
Concentration in Building after Dilution by Fresh Air in Void (Advective flow - no Barrier)																			
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr															
	Vapour concentration in outdoor air	C _o	0.00E+00	g/cm³															
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	6.143E-15	g/cm³									
									6.14E-03	µg/m³									
Concentration in Building after Dilution by Fresh Air in Void (Diffusive Flow - Vapour Barrier)																			
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr															
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	#DIV/0!	g/cm³									
									#DIV/0!	µg/m³									

		Contaminant: Naphthalene			Building Type: Small Terrace												
		HCV _{inh} (ID or TDSI):		0.82	=	2.87	Soil Type: Sand										
				µg/kg-d		µg/m³											
		Calculated Indoor Vapour Concentration from Equation 10 below for comparison with HCV _{inh}		C _{building}	1.34E-02	µg/m³											
Wilson eq				Input Parameters		units	Calculated Variables		units	Outputs		units					
Source Vapour Concentration in Soil Air from Soil Contamination																	
(2)	Soil Concentration	C _R	18	mg/kg	C _R	0.000018	g/g										
	Soil dry bulk density	ρ _b	1.18	g/cm³													
	Dimensionless Henry's Law constant (or K _{ow})	H _{TS}	0.00662	-													
	Soil air filled porosity	θ _a	0.3	cm³/cm³													
	Soil water filled porosity	θ _w	0.24	cm³/cm³	θ _t	0.54	cm³/cm³										
	Octanol-water partition coefficient	K _{oc}	645.65423	cm³/g													
	Soil fraction organic carbon	f _{oc}	0.029	-	K _d	18.723973	cm³/g	C _{source}	6.30E-09	g/cm³	6.30E+00	µg/m³					
Source Vapour Concentration in Soil Air from Groundwater Contamination																	
(3)	Groundwater concentration	C _w	43	µg/l	C _w	4.30E-08	g/cm³							equivalent soil concentration			
	Dimensionless Henry's Law constant (or K _{ow})	H _{TS}	0.00662	-			C _{source}	2.85E-10	g/cm³	0.81		mg/kg					
Source Vapour Concentration in Soil Air from NAPL																	
(4)	NAPL Mole fraction	X _i	-	-													
	Vapour Pressure	P _o	2.28E-05	atm													
	Moelcular Weight	MW	128.17	g/mol													
	Universal Gas Constant	R	8.21E-05	m³atm/molK													
	Soil Temperature	T	283.15	K			C _{source}	0.00E+00	g/cm³								
Combined Vapour Concentration from Soil, Groundwater and / or NAPL																	
	Sum of C _{source} calculated individually for soil, groundwater and NAPL.					C _{source}	6.58E-09	g/cm³									
Diffusive Flow from Ground to Void																	
(5)	Floor Area	A _b	2.80E+05	cm²													
	Soil (S), Water (W), NAPL (N) or (C) combined	Source Type	c	-													
	Vapour concentration at top of soil	C _{so}	0.00E+00	g/cm³													
	Diffusion coefficient in air	D _{air}	6.52E-02	cm²/s													
	Diffusion coefficient in water	D _{water}	5.16E-06	cm²/s	D _{eff}	4.08E-03	cm²/s										
	Depth to Source	L	60	cm			E	1.25E-07	g/s								
Concentration in Void after Dilution by Fresh Air in Void																	
(7)	Air Exchanges in Void	V _{ex}	1	1/day	T _{exchange}	86400	s										
	Void Height	H _{void}	150	cm	Q _{void}	486.11	cm³/s										
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³													
	Use Air exchange/day (1) or BS5925 (2)	1 or 2	1	-			C _{void}	2.58E-10	g/cm³								
Advective Flow from Void (Ground) Through Cracks into Building																	
(9)	Pressure difference	ΔP	3.1	Pa													
	Intrinsic permeability of floor slab	k _v	2.00E-07	cm²													
	Area of cracks in floor salb	A _{crack}	423.3	cm²													
	Viscosity of air	μ	1.80E-05	Pa s													
	thickness of floor salb	D _{crack}	15	cm			Q _{entry}	2.51E-10	g/s								
Diffusive Flow from Void through slab/barrier into building																	
	Floor Area	A _b	2.80E+05	cm²													
	Vapour concentration in building	C _{so}		g/cm³													
	Effective Diffusion coefficient for whole slab (barrie	D _{eff}		cm²/s													
	Slab/barrier thickness	L		cm			Q _{entry}	#DIV/0!	g/s								
Concentration in Building after Dilution by Fresh Air in Void (Advective flow - no Barrier)																	
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr													
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³													
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	1.342E-14	g/cm³							
								1.34E-02	µg/m³								
Concentration in Building after Dilution by Fresh Air in Void (Diffusive Flow - Vapour Barrier)																	
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr													
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	#DIV/0!	g/cm³							
								#DIV/0!	µg/m³								

		Contaminant: Naphthalene			Building Type: Small Terrace													
		HCV _{inh} (ID or TDSI):		0.82	=	2.87	Soil Type:		Sand									
				µg/kg-d		µg/m³												
		Calculated Indoor Vapour Concentration from Equation 10 below for comparison with HCV _{inh}		C _{building}	1.60E-01	µg/m³												
Wilson eq		Input Parameters			units		Calculated Variables		units		Outputs		units					
Source Vapour Concentration in Soil Air from Soil Contamination																		
(2)	Soil Concentration	C _R	102	mg/kg	C _R	0.000102	g/g											
	Soil dry bulk density	ρ _b	1.18	g/cm³														
	Dimensionless Henry's Law constant (or K _{ow})	H' _{TS}	0.00662	-														
	Soil air filled porosity	θ _a	0.3	cm³/cm³														
	Soil water filled porosity	θ _w	0.24	cm³/cm³	θ _r	0.54	cm³/cm³											
	Octanol-water partition coefficient	K _{oc}	645.65423	cm³/g														
	Soil fraction organic carbon	f _{oc}	0.013	-	K _d	8.393505	cm³/g	C _{source}	7.85E-08	g/cm³	7.85E+01	µg/m³						
Source Vapour Concentration in Soil Air from Groundwater Contamination																		
(3)	Groundwater concentration	C _w	4.3	µg/l	C _w	4.30E-09	g/cm³											
	Dimensionless Henry's Law constant (or K _{ow})	H' _{TS}	0.00662	-					C _{source}	2.85E-11	g/cm³	equivalent soil concentration						
											0.04 mg/kg							
Source Vapour Concentration in Soil Air from NAPL																		
(4)	NAPL Mole fraction	X _i	-	-														
	Vapour Pressure	P _o	2.28E-05	atm														
	Moelcular Weight	MW	128.17	g/mol														
	Universal Gas Constant	R	8.21E-05	m³atm/molK														
	Soil Temperature	T	283.15	K					C _{source}	0.00E+00	g/cm³							
Combined Vapour Concentration from Soil, Groundwater and / or NAPL																		
	Sum of C _{source} calculated individually for soil, groundwater and NAPL.					C _{source}	7.86E-08	g/cm³										
Diffusive Flow from Ground to Void																		
(5)	Floor Area	A _b	2.80E+05	cm²														
	Soil (S), Water (W), NAPL (N) or (C) combined	Source Type	c	-														
	Vapour concentration at top of soil	C _{so}	0.00E+00	g/cm³														
	Diffusion coefficient in air	D _{air}	6.52E-02	cm²/s														
	Diffusion coefficient in water	D _{water}	5.16E-06	cm²/s	D _{eff}	4.08E-03	cm²/s											
	Depth to Source	L	60	cm					E	1.50E-06	g/s							
Concentration in Void after Dilution by Fresh Air in Void																		
(7)	Air Exchanges in Void	V _{ex}	1	1/day	T _{exchange}	86400	s											
	Void Height	H _{void}	150	cm	Q _{void}	486.11	cm³/s											
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³														
	Use Air exchange/day (1) or BS5925 (2)	1 or 2	1	-					C _{void}	3.08E-09	g/cm³							
Advective Flow from Void (Ground) Through Cracks into Building																		
(9)	Pressure difference	ΔP	3.1	Pa														
	Intrinsic permeability of floor slab	k _v	2.00E-07	cm²														
	Area of cracks in floor salb	A _{crack}	423.3	cm²														
	Viscosity of air	μ	1.80E-05	Pa s														
	thickness of floor salb	D _{crack}	15	cm					Q _{entry}	2.99E-09	g/s							
Diffusive Flow from Void through slab/barrier into building																		
	Floor Area	A _b	2.80E+05	cm²														
	Vapour concentration in building	C _{so}		g/cm³														
	Effective Diffusion coefficient for whole slab (barrier)	D _{eff}		cm²/s														
	Slab/barrier thickness	L		cm					Q _{entry}	#DIV/0!	g/s							
Concentration in Building after Dilution by Fresh Air in Void (Advective flow - no Barrier)																		
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr														
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³														
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	1.603E-13	g/cm³								
										1.60E-01	µg/m³							
Concentration in Building after Dilution by Fresh Air in Void (Diffusive Flow - Vapour Barrier)																		
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr														
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	#DIV/0!	g/cm³								
										#DIV/0!	µg/m³							

		Contaminant: Aliphatic EC >10-12				Building Type: Small Terrace											
		HCV _{inh} (ID or TDSI):	145	=	507.5		Soil Type: Sand										
			µg/kg-d		µg/m³												
		Calculated Indoor Vapour Concentration from Equation 10 below for comparison with HCV _{inh}	C _{building}	2.48E+01	µg/m³												
Wilson eq		Input Parameters			units	Calculated Variables			units	Outputs			units				
Source Vapour Concentration in Soil Air from Soil Contamination																	
(2)	Soil Concentration	C _R	126	mg/kg	C _R	0.000126	g/g										
	Soil dry bulk density	ρ _b	1.18	g/cm³													
	Dimensionless Henry's Law constant (or K _{ow})	H' _{TS}	64.4	-													
	Soil air filled porosity	Θ _a	0.3	cm³/cm³													
	Soil water filled porosity	Θ _w	0.24	cm³/cm³	Θ _i	0.54	cm³/cm³										
	Octanol-water partition coefficient	K _{oc}	239883.29	cm³/g													
	Soil fraction organic carbon	f _{oc}	0.0058	-	K _d	1391.3231	cm³/g	C _{source}	5.76E-06	g/cm³	5.76E+03	µg/m³					
Source Vapour Concentration in Soil Air from Groundwater Contamination																	
(3)	Groundwater concentration	C _w	117	µg/l	C _w	1.17E-07	g/cm³									equivalent soil concentration	
	Dimensionless Henry's Law constant (or K _{ow})	H' _{TS}	64.4	-				C _{source}	7.53E-06	g/cm³	164.72	mg/kg					
Source Vapour Concentration in Soil Air from NAPL																	
(4)	NAPL Mole fraction	X _i	-	-													
	Vapour Pressure	P _o	0.0003168	atm													
	Moelcular Weight	MW	160	g/mol													
	Universal Gas Constant	R	8.21E-05	m³atm/molK													
	Soil Temperature	T	283.15	K				C _{source}	0.00E+00	g/cm³							
Combined Vapour Concentration from Soil, Groundwater and / or NAPL																	
	Sum of C _{source} calculated individually for soil, groundwater and NAPL.							C _{source}	1.33E-05	g/cm³							
Diffusive Flow from Ground to Void																	
(5)	Floor Area	A _b	2.80E+05	cm²													
	Soil (S), Water (W), NAPL (N) or (C) combined	Source Type	c	-													
	Vapour concentration at top of soil	C _{so}	0.00E+00	g/cm³													
	Diffusion coefficient in air	D _{air}	1.00E-01	cm²/s													
	Diffusion coefficient in water	D _{water}	1.00E-05	cm²/s	D _{eff}	6.22E-03	cm²/s										
	Depth to Source	L	100	cm				E	2.32E-04	g/s							
Concentration in Void after Dilution by Fresh Air in Void																	
(7)	Air Exchanges in Void	V _{ex}	1	1/day	T _{exchange}	86400	s										
	Void Height	H _{void}	150	cm	Q _{void}	486.11	cm³/s										
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³													
	Use Air exchange/day (1) or BS5925 (2)	1 or 2	1	-				C _{void}	4.77E-07	g/cm³							
Advective Flow from Void (Ground) Through Cracks into Building																	
(9)	Pressure difference	ΔP	3.1	Pa													
	Intrinsic permeability of floor slab	k _v	2.00E-07	cm²													
	Area of cracks in floor salb	A _{crack}	423.3	cm²													
	Viscosity of air	μ	1.80E-05	Pa s													
	thickness of floor salb	D _{crack}	15	cm				Q _{entry}	4.63E-07	g/s							
Diffusive Flow from Void through slab/barrier into building																	
	Floor Area	A _b	2.80E+05	cm²													
	Vapour concentration in building	C _{so}		g/cm³													
	Effective Diffusion coefficient for whole slab (barrie	D _{eff}		cm²/s													
	Slab/barrier thickness	L		cm				Q _{entry}	#DIV/0!	g/s							
Concentration in Building after Dilution by Fresh Air in Void (Advective flow - no Barrier)																	
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr													
	Vapour concentration in outdoor air	C _e	0.00E+00	g/cm³													
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	2.482E-11	g/cm³							
									2.48E+01	µg/m³							
Concentration in Building after Dilution by Fresh Air in Void (Diffusive Flow - Vapour Barrier)																	
(10)	Air exchange rate in building	B _{ex}	0.5	1/hr													
	Buiding height	H	480	cm	Q _{building}	1.87E+04	cm³/s	C _{building}	#DIV/0!	g/cm³							
									#DIV/0!	µg/m³							

Appendix E
PAH Double Ratio Plots



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Appendix C

Model Outputs

Contaminant	Target Concentration	Target Concentration Type	Concentration in source area	Distance from source area	Hydraulic conductivity of aquifer	Hydraulic gradient	Effective porosity of aquifer materials	Groundwater flow velocity	Organic carbon partition coefficient	Fraction of organic carbon in aquifer	Soil-Water Partitioning Coefficient	Bulk density of aquifer materials	Retardation factor	Contaminant flow rate	Longitudinal dispersivity	Transverse dispersivity	Vertical dispersivity	Contaminant Half-Life	First order decay rate	First order decay rate applied to dissolved phase only	Plume thickness at source	Width of plume at source	erf(vertical)	erf(transverse)	Concentration at x
CT	mg/L	CT	mg/L	x	K	i	n	V	Koc	Foc	Kd	p	Rf	u	ax	az	ay	T1/2	λ	λ	Sy	Sz			CED
				m	m/day	m/m	fraction	m/day	L/kg	fraction	L/kg	g/cm3	factor	m/day	m	m	m	days	1/day	1/day	m	m			mg/L
Aliphatics C5-6	15	DWS	0.014	50	0.00864	0.03	0.3	0.0009	813	0.014	11.38	1.7	65.5	1.32E-05	5	0.5	0.05	500	0.0014	2.12E-05	18	300	1.000	1.000	6.72E-13
Aliphatics C6-8	15	DWS	0.03	50	0.00864	0.03	0.3	0.0009	3802	0.014	53.23	1.7	302.6	2.86E-06	5	0.5	0.05	500	0.0014	4.58E-06	18	300	1.000	1.000	1.44E-12
Aliphatics C8-10	0.3	DWS	0.025	50	0.00864	0.03	0.3	0.0009	30200	0.014	422.79	1.7	2396.8	3.60E-07	5	0.5	0.05	500	0.0014	5.78E-07	18	300	1.000	1.000	1.20E-12
Aliphatics C10-12	0.3	DWS	0.117	50	0.00864	0.03	0.3	0.0009	239883	0.014	3358.37	1.7	19031.7	4.54E-08	5	0.5	0.05	1000	0.0007	3.64E-08	18	300	1.000	1.000	1.89E-08
Aliphatics C12-16	0.3	DWS	0.185	50	0.00864	0.03	0.3	0.0009	5370318	0.014	75184.45	1.7	426046.2	2.03E-09	5	0.5	0.05	1000	0.0007	1.63E-09	18	300	1.000	1.000	2.98E-08
Aliphatics C16-35	0.3	DWS	4.85	50	0.00864	0.03	0.3	0.0009	575439937.3	0.014	8056159.12	1.7	45651569.4	1.89E-11	5	0.5	0.05	1000	0.0007	1.52E-11	18	300	1.000	1.000	7.82E-07
Aromatics EC5-7 (Benzene)	0.01	EQS	0.01	50	0.00864	0.03	0.3	0.0009	68	0.014	0.95	1.7	6.4	1.36E-04	5	0.5	0.05	500	0.0014	2.18E-04	18	300	1.000	1.000	4.80E-13
Aromatics EC7-8 (Toluene)	0.074	EQS	0.01	50	0.00864	0.03	0.3	0.0009	204	0.014	2.86	1.7	17.2	5.02E-05	5	0.5	0.05	500	0.0014	8.06E-05	18	300	1.000	1.000	4.80E-13
Aromatics EC8-10	0.3	DWS	0.026	50	0.00864	0.03	0.3	0.0009	1585	0.014	22.19	1.7	126.7	6.82E-06	5	0.5	0.05	500	0.0014	1.09E-05	18	300	1.000	1.000	1.25E-12
Aromatics EC10-12	0.09	DWS	0.078	50	0.00864	0.03	0.3	0.0009	2512	0.014	35.17	1.7	200.3	4.31E-06	5	0.5	0.05	1000	0.0007	3.46E-06	18	300	1.000	1.000	1.26E-08
Aromatics EC12-16	0.09	DWS	0.101	50	0.00864	0.03	0.3	0.0009	5012	0.014	70.17	1.7	398.6	2.17E-06	5	0.5	0.05	1000	0.0007	1.74E-06	18	300	1.000	1.000	1.63E-08
Aromatics EC16-21	0.09	DWS	0.257	50	0.00864	0.03	0.3	0.0009	14125	0.014	197.76	1.7	1121.6	7.70E-07	5	0.5	0.05	1000	0.0007	6.18E-07	18	300	1.000	1.000	4.14E-08
Aromatics EC21-35	0.09	DWS	1.28	50	0.00864	0.03	0.3	0.0009	125893	0.014	1762.50	1.7	9988.5	8.65E-08	5	0.5	0.05	1000	0.0007	6.94E-08	18	300	1.000	1.000	2.06E-07
TPH	0.01	EQS	6.59	50	0.00864	0.03	0.3	0.0009	68	0.014	0.95	1.7	6.4	1.36E-04	5	0.5	0.05	1000	0.0007	1.09E-04	18	300	1.000	1.000	1.06E-06
Benzo(a)pyrene	0.00027	MAC EQS	0.023	50	0.00864	0.03	0.3	0.0009	128825	0.014	1803.5	1.7	10221.1	8.45E-08	5	0.5	0.05	1000	0.0007	6.78E-08	18	300	1.000	1.000	3.71E-09
Benzo(b)fluoranthene	0.000017	MAC EQS	0.0332	50	0.00864	0.03	0.3	0.0009	104713	0.014	1466.0	1.7	8308.2	1.04E-07	5	0.5	0.05	1000	0.0007	8.34E-08	18	300	1.000	1.000	5.35E-09
Benzo(k)fluoranthene	0.000017	MAC EQS	0.0149	50	0.00864	0.03	0.3	0.0009	147911	0.014	2070.8	1.7	11735.3	7.36E-08	5	0.5	0.05	1000	0.0007	5.91E-08	18	300	1.000	1.000	2.40E-09
Benzo(ghi)perylene	0.0000082	MAC EQS	0.0232	50	0.00864	0.03	0.3	0.0009	416869	0.014	5836.2	1.7	33072.6	2.61E-08	5	0.5	0.05	1000	0.0007	2.10E-08	18	300	1.000	1.000	3.74E-09
Indeno(123-cd)perylene	0.0001	DWS	0.0221	50	0.00864	0.03	0.3	0.0009	87096	0.014	1219.3	1.7	6910.6	1.25E-07	5	0.5	0.05	1000	0.0007	1.00E-07	18	300	1.000	1.000	3.56E-09
Naphthalene	0.13	MAC EQS	0.0043	50	0.00864	0.03	0.3	0.0009	646	0.014	9.0	1.7	52.2	1.65E-05	5	0.5	0.05	1000	0.0007	1.33E-05	18	300	1.000	1.000	6.93E-10
Fluoranthene	0.00012	MAC EQS	0.0197	50	0.00864	0.03	0.3	0.0009	18197	0.014	254.8	1.7	1444.6	5.98E-07	5	0.5	0.05	1000	0.0007	4.80E-07	18	300	1.000	1.000	3.17E-09
Anthracene	0.0001	EQS	0.00521	50	0.00864	0.03	0.3	0.0009	5623	0.014	78.7	1.7	447.1	1.93E-06	5	0.5	0.05	1000	0.0007	1.55E-06	18	300	1.000	1.000	8.40E-10
Phenol	0.0077	EQS	0.37	50	0.00864	0.03	0.3	0.0009	29	0.014	0.4	1.7	3.3	2.63E-04	5	0.5	0.05	300	0.0023	7.03E-04	18	300	1.000	1.000	5.16E-15
Chloroform	0.0001	DWS	0.00296	50	0.00864	0.03	0.3	0.0009	50	0.014	0.7	1.7	5.0	1.74E-04	5	0.5	0.05	200	0.0035	6.96E-04	18	300	1.000	1.000	1.19E-20
Bis(2-ethylhexyl)phthalate	0.008	DWS	0.104	50	0.00864	0.03	0.3	0.0009	158489	0.014	2218.9	1.7	12574.5	6.87E-08	5	0.5	0.05	300	0.0023	1.84E-07	18	300	1.000	1.000	1.45E-15
PFOS	0.00005	DWS	0.000102	50	0.00864	0.03	0.3	0.0009	1000	0.014	14.0	1.7	80.3	1.08E-05	5	0.5	0.05	1.50E+04	0.0000	5.76E-07	18	300	1.000	1.000	1.13E-05
Arsenic	0.01	DWS	0.0356	50	0.00864	0.03	0.3	0.0009	0	0.014	500	1.7	2834.3	3.05E-07	5	0.5	0.05	9.90E+99	0.0000	2.47E-104	18	300	1.000	1.000	0.036
Boron	2	EQS	54.8	50	0.00864	0.03	0.3	0.0009	0	0.014	10	1.7	57.7	1.50E-05	5	0.5	0.05	9.90E+99	0.0000	1.21E-102	18	300	1.000	1.000	54.80
Cadmium	0.00025	EQS	0.011	50	0.00864	0.03	0.3	0.0009	0	0.014	100	1.7	567.7	1.52E-06	5	0.5	0.05	9.90E+99	0.0000	1.23E-103	18	300	1.000	1.000	0.0110
Chromium	0.0047	EQS	0.0107	50	0.00864	0.03	0.3	0.0009	0	0.014	4800	1.7	27201.0	3.18E-08	5	0.5	0.05	9.90E+99	0.0000	2.57E-105	18	300	1.000	1.000	0.0107
Copper	0.02146	PNEC	0.14	50	0.00864	0.03	0.3	0.0009	0	0.014	100	1.7	567.7	1.52E-06	5	0.5	0.05	9.90E+99	0.0000	1.23E-103	18	300	1.000	1.000	0.14
Lead	0.00678	PNEC	0.0139	50	0.00864	0.03	0.3	0.0009	0	0.014	1000	1.7	5667.7	1.52E-07	5	0.5	0.05	9.90E+99	0.0000	1.24E-104	18	300	1.000	1.000	0.0139
Manganese	0.17354	PNEC	3.88	50	0.00864	0.03	0.3	0.0009	0	0.014	720	1.7	4081.0	2.12E-07	5	0.5	0.05	9.90E+99	0.0000	1.72E-104	18	300	1.000	1.000	3.88
Nickel	0.01216	PNEC	0.13	50	0.00864	0.03	0.3	0.0009	0	0.014	500	1.7	2834.3	3.05E-07	5	0.5	0.05	9.90E+99	0.0000	2.47E-104	18	300	1.000	1.000	0.130
Selenium	0.01	DWS	0.0118	50	0.00864	0.03	0.3	0.0009	0	0.014	50	1.7	284.3	3.04E-06	5	0.5	0.05	9.90E+99	0.0000	2.46E-103	18	300	1.000	1.000	0.0118
Zinc	0.0302	PNEC	0.0545	50	0.00864	0.03	0.3	0.0009	0	0.014	38	1.7	216.3	3.99E-06	5	0.5	0.05	9.90E+99	0.0000	3.24E-103	18	300	1.000	1.000	0.0545
Iron	1	EQS	11	50	0.00864	0.03	0.3	0.0009	0	0.014	810	1.7	4591.0	1.88E-07	5	0.5	0.05	9.90E+99	0.0000	1.52E-104	18	300	1.000	1.000	11.00
Sulphate	250	DWS	807	50	0.00864	0.03	0.3	0.0009	0	0.014		1.7	1.0	8.64E-04	5	0.5	0.05		#DIV/0!	#DIV/0!	18	300	1.000	1.000	#DIV/0!
Total Cyanide	0.001	EQS	0.18	50	0.00864	0.03	0.3	0.0009	0	0.014	5.0	1.7	29.3	2.95E-05	5	0.5	0.05	24	0.0289	9.84E-04	18	300	1.000	1.000	1.76E-55
Thiocyanate	0.001	EQS	0.12	50	0.00864	0.03	0.3	0.0009	0	0.014	5.0	1.7	29.3	2.95E-05	5	0.5	0.05	24	0.0289	9.84E-04	18	300	1.000	1.000	0.00

Contaminant	CT	Target Concentration	CT	Target Concentration Type	Concentration in source area	Distance from source area	Hydraulic conductivity of aquifer	Hydraulic gradient	Effective porosity of aquifer materials	Groundwater flow velocity	Organic carbon partition coefficient	Fraction of organic carbon in aquifer	Soil-Water Partitioning Coefficient	Bulk density of aquifer materials	Retardation factor	Contaminant flow rate	Longitudinal dispersivity	Transverse dispersivity	Vertical dispersivity	Contaminant Half-Life	First order decay rate	First order decay rate applied to dissolved phase only	Plume thickness at source	Width of plume at source	erf(vertical)	erf(transverse)	Concentration at x
	mg/L				C0	x	K	i	n	V	Koc	Foc	Kd	p	Rf	u	ax	az	ay	T1/2	λ	λ	Sy	Sz			CED
	mg/L				mg/L	m	m/day	m/m	fraction	m/day	L/kg	fraction	L/kg	g/cm3	factor	m/day	m	m	m	days	1/day	1/day	m	m			mg/L
Boron	2	EQS			54.8	250	0.00864	0.03	0.3	0.0009	0	0.014	10	1.7	57.7	1.50E-05	25	2.5	0.25	9.90E+99	0.0000	1.21E-102	18	300	0.579	1.000	31.74
Cadmium	0.00025	EQS			0.011	250	0.00864	0.03	0.3	0.0009	0	0.014	100	1.7	567.7	1.52E-06	25	2.5	0.25	9.90E+99	0.0000	1.23E-103	18	300	0.579	1.000	0.0064
Chromium	0.0047	EQS			0.0107	250	0.00864	0.03	0.3	0.0009	0	0.014	4800	1.7	27201.0	3.18E-08	25	2.5	0.25	9.90E+99	0.0000	2.57E-105	18	300	0.579	1.000	0.0062
Copper	0.02146	PNEC			0.14	250	0.00864	0.03	0.3	0.0009	0	0.014	100	1.7	567.7	1.52E-06	25	2.5	0.25	9.90E+99	0.0000	1.23E-103	18	300	0.579	1.000	0.08
Manganese	0.17354	PNEC			3.88	250	0.00864	0.03	0.3	0.0009	0	0.014	720	1.7	4081.0	2.12E-07	25	2.5	0.25	9.90E+99	0.0000	1.72E-104	18	300	0.579	1.000	2.25
Nickel	0.01216	PNEC			0.13	250	0.00864	0.03	0.3	0.0009	0	0.014	500	1.7	2834.3	3.05E-07	25	2.5	0.25	9.90E+99	0.0000	2.47E-104	18	300	0.579	1.000	0.075
Selenium	0.01	DWS			0.0118	250	0.00864	0.03	0.3	0.0009	0	0.014	50	1.7	284.3	3.04E-06	25	2.5	0.25	9.90E+99	0.0000	2.46E-103	18	300	0.579	1.000	0.0068
Zinc	0.0302	PNEC			0.0545	250	0.00864	0.03	0.3	0.0009	0	0.014	38	1.7	216.3	3.99E-06	25	2.5	0.25	9.90E+99	0.0000	3.24E-103	18	300	0.579	1.000	0.0316
Iron	1	EQS			11	250	0.00864	0.03	0.3	0.0009	0	0.014	810	1.7	4591.0	1.88E-07	25	2.5	0.25	9.90E+99	0.0000	1.52E-104	18	300	0.579	1.000	6.37
Sulphate	250	DWS			807	250	0.00864	0.03	0.3	0.0009	0	0.014		1.7	1.0	8.64E-04	25	2.5	0.25		#DIV/0!	#DIV/0!	18	300	0.579	1.000	#DIV/0!
Total Cyanide	0.001	EQS			0.18	250	0.00864	0.03	0.3	0.0009	0	0.014	5.0	1.7	29.3	2.95E-05	25	2.5	0.25	24	0.0289	9.84E-04	18	300	0.579	1.000	4.34E-125
Thiocyanate	0.001	EQS			0.12	250	0.00864	0.03	0.3	0.0009	0	0.014	5.0	1.7	29.3	2.95E-05	25	2.5	0.25	24	0.0289	9.84E-04	18	300	0.579	1.000	0.00

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