

Appendix 10.6

Contaminated Land

Assessment

Transport Scotland

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1. Introduction

- 1.1.1. This technical appendix provides a detailed overview of the findings of the Stage 2 Ground Investigation (GI) and of the subsequent assessment undertaken using the GI data. Assessments of the risk to human health, the water environment, and the risk from ground gas and phytotoxicity have been carried out and this appendix provides methodologies and a summary of the results of these assessments. This appendix is intended to be read in conjunction with Chapter 10 Geology, Soils and Groundwater.
- 1.1.2. The general risk assessment methodology used for the scheme is similar to that derived for the determination of statutory Contaminated Land, as defined in Part IIA of the Environmental Protection Act 1990 (as amended). Contaminated Land is assessed through the identification and assessment of pollutant linkages (source-pathway-receptor relationships). Implicit in associated guidance is the application of risk assessment to consider whether potential pollutant linkages may be significant (unacceptable risk) or not.
- 1.1.3. In Scotland, the requirement to consider contaminated land within the planning process is specified through Planning Advisory Note (PAN) 33ⁱ Development of Contaminated Land and supporting authoritative guidance document CLR11ⁱⁱ.
- 1.1.4. The basic approach to risk assessment used at Design Manual for Roads and Bridges (DMRB) Stage 3 follows the principles given in CLR11, i.e. that decisions regarding a site may be informed by:
- Tier 1 preliminary risk assessment (PRA)- typically a desk study review and site walkover inspection with an assessment of risk considering the likelihood and severity of the potential consequences associated with the pollutant linkage(s);
 - Tier 2 generic quantitative risk assessment - a review of site investigation and monitoring data, the development of a Conceptual Site Model (CSM) with an assessment of risk using precautionary, Generic Assessment Criteria (GACs) relevant to the pollutant linkage(s) that represent minimal or tolerable risk; or
 - Tier 3 detailed quantitative risk assessment - an assessment of risk based on the use of detailed ground investigation and monitoring data to develop a CSM and using Site Specific Assessment Criteria (SSACs) relevant to the pollutant linkage(s) to identify the likelihood of unacceptable risk.
- 1.1.5. A contaminated land Tier 1 PRA has previously been undertaken for the A9 Dualling Dalraddy to Slochd project, and was reported within the Geotechnical PSSRⁱⁱⁱ. The aims of the PRA were to identify sites of potential historic contamination within the Proposed Scheme study area and assess the potential risks posed to human health and the wider environment in the context of the proposed scheme. Drawings showing the study area are included within Appendix A. The PRA was reassessed at DMRB Stage 3 and the updated information is included in Chapter 10 Geology and Soils.
- 1.1.6. In accordance with CLR11, the risk assessment methodology involved the development of a CSM for the site. The CSM represents a network of relationships between potential sources of contamination and receptors via various potential pollution pathways. Where a source, pathway and receptor combination exists, this is referred to as a complete pollutant linkage. As part of the Tier 1 PRA, a preliminary qualitative risk assessment was undertaken in accordance with CIRIA C552^{iv}.

- 1.1.7. The Tier 1 PRA found that potential **Moderate / Low** environmental liabilities existed relating to the possible presence of contamination and its likely impact on the environment.

2. Stage 2 Ground Investigation

- 2.1.1. GI (Stage 2 GI) was carried out at the Proposed Scheme between February and April 2017 with additional gas and groundwater monitoring carried out during May and June 2017. This work allowed for the chemical testing of representative soil samples of the underlying deposits as well as testing of groundwater and surface water samples taken from within the study area. Gas monitoring was also taken at selected borehole installations. The GI provided visual and olfactory evidence of presence or absence of contamination within the footprint of the proposed scheme and within the wider study area.
- 2.1.2. The factual information pertaining to these works was reported in the A9 Dualling: Dalraddy to Slochd Report on Stage 2 Preliminary Ground Investigation^v and this report contains plans showing all exploratory hole locations. Exploratory hole locations relevant to the contaminated land assessment are also shown on the drawings provided in Appendix A.
- 2.1.3. For the Stage 2 GI 104 boreholes were sunk by a mixture of cable percussion, sonic and rotary open-hole and core drilling methods; and 87 trial pits were excavated by hand and mechanical means.
- 2.1.4. In addition to geotechnical and hydrogeological testing, geochemical testing was carried out on selected samples. Geochemical testing was carried out on 111 soil samples including the analysis of 27 samples for soil leachability testing. 18 groundwater samples were also taken during a single round of groundwater sampling from selected groundwater monitoring wells with a further 12 surface water samples also retrieved from adjacent surface water courses during this monitoring. All monitoring wells were developed prior to sampling to ensure groundwater samples were representative of site conditions. Up to five rounds of ground gas monitoring were also carried out in all monitoring installations (70 No.) between April 2017 and September 2017. All testing was carried out in line with authoritative guidance.
- 2.1.5. During the Stage 2 GI, made ground was identified in 39 out of 191 exploratory holes although at the majority of these locations made ground was found to be a reworked natural sandy gravel material with no evidence of anthropogenic materials and no visual/olfactory evidence of contamination. Made Ground was noted to depths of up to 3.0 m below ground level (bgl).
- 2.1.6. Representative soil samples of the underlying made ground deposits were taken during the ground investigation and these were scheduled for chemical testing to provide a good horizontal and vertical coverage of the underlying deposits and to target potentially contaminated materials or former land uses.
- 2.1.7. Table 1 below provides details of historical land uses targeted during the Stage 2 ground investigation and the material that was identified at each of these locations. As detailed within Chapter 10, Geology, Soils and Groundwater, former land uses represent potential sources of contamination and the GI allowed for further investigation to be carried out at these increased risk areas. The locations of the exploratory holes provided in Table 1 are identified on the drawings in Appendix A.

2.1.8. Further Stage 3 GI is currently underway and this additional investigation aims to target the remaining potential sources highlighted in the PRA which were not covered by the Stage 2 GI. Information from the Stage 3 investigation was not available at the time of writing.

Table 2.1: Targeted historical land uses within the Stage 2 GI Exploratory Holes

Exploratory Hole Reference	Associated historical land use	Made Ground description (if present)	Scheduled Testing Depth (testing suites)
BHDS2074	Potentially infilled land	Reworked natural material (sand and gravel) identified to a depth of 1.25m bgl. No visual / olfactory evidence of contamination noted.	0.30m, 1.0m and 2.0m (soil)
BHDS2075	Downgradient of a tank	Gravelly sand (logged as possible made ground) recorded to a depth of 1.20 m bgl. No visual / olfactory evidence of contamination within natural superficial deposits. Borehole terminated within granite.	0.5m, 1.0m (soil)
BHDS2076	By dairy farm	Silty sand and gravel with fragments of timber and concrete identified to a depth of 1.0 m bgl. Visual / olfactory evidence of hydrocarbon contamination (hydrocarbon film and odour) at 5.10 m to 6.50 m bgl within natural deposits (sandy gravel).	0.50m, 5.1m, 5.5m, 6.5m and 9.5m (soil)
BHDS2077	Potential infilled water feature	No made ground noted.	1.0m (soil and leachate) 1.3m, 7.0m (soil)
BHDS2078	Potential infilled water feature	Sandy gravel (logged as possible made ground) recorded to a depth of 2.05 m bgl. No visual or olfactory evidence of contamination were noted.	1.0m (soil)

2.1.9. GI was also located at the approximate position of other former land uses identified within the PRA although these exploratory holes were not specifically targeted at these land uses. These instances are detailed in Table 2 below which shows that made ground was not identified at any of these locations. The locations of the exploratory holes provided in Table 2 are identified on the drawings in Appendix A.

Table 2.2: Additional historical land uses coinciding within the Stage 2 GI

Exploratory Hole Reference	Associated historical land use	Made Ground description (if present)	Scheduled Testing Depth (testing suites)
BHDS2005	Disused gravel pit	No made ground noted.	0.50m and 2.0m (soil)
BHDS2028	Sawmill / derelict land	No made ground noted.	0.5m and 1.0m (soil and leachate)
BHDS2030	Unidentified potentially contaminated land	No made ground noted.	Not testing scheduled.
BHDS2056	Former quarry	No made ground noted.	Not testing scheduled.

- 2.1.10. Four further ground investigation locations (BH2069, BH2072, BH2073, and BH2079) were scheduled to aid the chemical characterisation of the underlying deposits at locations of selected cuttings included as part of the Proposed Scheme. Only the exploratory hole for BH2079 identified made ground material (reworked natural to a depth of 1.20 m bgl) with the other four locations identifying only natural materials. Appropriate chemical testing to allow characterisation of materials was carried out at all five locations.
- 2.1.11. Table 3 below provides details of the GI locations where made ground showing evidence of anthropogenic materials and / or visual / olfactory evidence of contamination was identified within the exploratory holes at locations where former land uses had not been previously identified. Reworked natural materials showing no man-made constituents, and continuous tarmacadam layers (existing road pavement) have been omitted from this table. A description of chemical testing (soil and soil leachate testing) undertaken at each location to characterise these materials is also detailed in this table. The location of each of these exploratory holes is provided within the Stage 2 factual reportⁱⁱⁱ. The locations of the exploratory holes provided in Table 3 are identified on the drawings in Appendix A.

Table 2.3: Evidence of Contamination within the Stage 2 GI Exploratory Holes

Exploratory Hole Reference	Description	Depth to layer	Scheduled Testing Depth (testing suites)
BHDS2011	MADE GROUND (light brownish yellow slightly silty sand and gravel with occasional fragments of tarmac and pockets of clayey sand) (Overlain by tarmac layer)	0.10 – 0.30	No testing scheduled.
BHDS2070A	MADE GROUND (dark brown sandy slightly silty gravel with occasional fragments of tarmac, cobbles and boulders. (Slight hydrocarbon odour)	0.40 – 3.0	1.0m (soil and leachate)
TPDS2014	MADE GROUND (dark brown sandy silty gravel with occasional rootlets, some wood, plastic, concrete, brick and high cobble content.	0.3 – 1.6	0.50m (soil and leachate), 1.0m (soil)
TPDS2022	MADE GROUND (brown very sandy silty gravel with many	0.2 – 1.4	0.50m (soil and leachate), 1.0m (soil)

Exploratory Hole Reference	Description	Depth to layer	Scheduled Testing Depth (testing suites)
	rootlets, some broken brick, occasional pockets of organic material, high cobble content and high boulder content.		
TPDS2031	MADE GROUND (dark grey slightly gravelly clayey sand with occasional fragments of wood and timber	0.35 – 0.6	0.50m (soil)
TPDS2040	MADE GROUND (brown sandy gravelly silty topsoil with many rootlets, some bricks and medium cobble and boulder content.	0 – 0.40	0.30m (soil),
TPDS2063A	MADE GROUND (dark brown sandy gravelly pseudofibrous peat with occasional timber and rootlets	0 – 1.5	No testing scheduled
TPDS2065	MADE GROUND (dark brownish black sandy slightly silty gravel with occasional rootlets, some asphalt, ash and high cobble content. (Strong hydrocarbon odour throughout). Possible asbestos pipe at 1.20 m bgl.	0.8 – 1.20	0.30m, 0.50m, 0.80m, 1.0m (soils)
TPDS2072	MADE GROUND (light orange brown silty sand and gravel with occasional metal, some rootlets and medium cobble content.	0.15 – 1.40	0.50m, 1.0m (soil)

2.1.12. With relation to the soil testing detailed in Tables 1 to 3, this was carried out on 111 soil samples by a UKAS accredited laboratory and comprised the following chemical testing parameters:

- Inorganics – pH, cyanide (free, total and complex) and asbestos presence and type (selected samples only);
- Metals – arsenic, cadmium, chromium (total and hexavalent), lead, mercury, selenium, copper, nickel, zinc, vanadium; and,
- Organics – speciated Polycyclic Aromatic Hydrocarbons (PAH) (USEPA 16), speciated Total Petroleum Hydrocarbons (TPH) Criteria Working Group (CWG), BTEX (benzene, toluene, ethylbenzene, xylene), MTBE (methyl tert-butyl ether), Volatile Organic Compounds (VOCs), Semi-volatile Organic Compounds (SVOCs). Polychlorinated Biphenyls (PCBs) (congeners). Note that BTEX, MTBE, VOCs, SVOCs, and PCBs were only scheduled on selected samples.

2.1.13. Chemical testing parameters within the soil leachate testing suite was carried out on 27 soil samples by a UKAS accredited laboratory and comprised the following chemical testing parameters:

- Inorganics – pH, cyanide (total), chloride, ammoniacal nitrogen, sulphide, sulphate;
- Metals – boron, arsenic, cadmium, chromium (total), lead, mercury, selenium, copper, nickel, zinc, calcium, magnesium, iron; and,

- Organics – speciated PAH (USEPA 16), speciated TPH (CWG).

2.1.14. Groundwater samples were taken from 18 selected borehole installations at the proposed scheme during a single round of sampling in June 2016. Similarly, surface water samples were collected from defined locations during the GI in April 2017. Surface water sampling locations and relevant borehole locations are provided on the drawings provided in Annex A and the Stage 2 factual report. All water samples were scheduled for laboratory analysis and testing parameters for the groundwater and surface water testing suites comprised the following:

- Inorganics – pH, cyanide (total, free and complex), thiocyanate, ammoniacal nitrogen, sulphide, sulphate, chloride, nitrate, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved organic carbon (DOC), hardness and electrical conductivity;
- Metals – boron, arsenic, cadmium, chromium (total and hexavalent), lead, mercury, selenium, copper, nickel, zinc, aluminium, antimony, barium, beryllium, calcium, manganese, molybdenum, iron; and,
- Organics – speciated PAH (USEPA 16), speciated TPH (CWG).

2.1.15. Further targeted intrusive investigation and chemical testing of soils, groundwater and surface water from within the study area is proposed as part of the Stage 3 GI which is currently underway. This will allow for further assessment of the level of risk posed by the pollutant linkages detailed within the CSM and further targeting of potential historical sources of contamination not targeted during the stage 2 GI.

3. Assessment

3.1.1. The results of the contamination testing from the Stage 2 GI were screened and assessed against relevant standards as detailed in the Sections below.

3.2. Human Health Risk Assessment

Methodology

3.2.1. Based on the Tier 1 PRA and ground model provided in Chapter 10, Geology and Soils, a Tier 2 Generic Quantitative Risk Assessment (GQRA) for human health has been undertaken in accordance with Environment Agency / Defra guidance documents CLR11 and SR2^{vi}/SR3^{vii} (SC050021 Series).

3.2.2. A Tier 2 GQRA has been undertaken for the potential human health pollutant linkages and this has been based on the screening of soil data against relevant generic assessment criteria (GAC) where these are available.

3.2.3. The source of the GAC used for the assessment include the following which are in line with other Stage 3 reports produced for the A9 Dualling project. These sources are arranged below in the order of preference that was used in the selection of GAC:

- LQM / CIEH Generic Assessment Criteria (GAC)^{viii}
- EIC / AGS / CL:AIRE GAC^{ix};
- Atkins' Soil Screening Values (SSVs)^x;
- Defra Category 4 Screening Levels (C4SLs)^{xi};

- 3.2.4. It should be noted that GACs are liable to change as new policy and technical guidance, including toxicological data, is published by the Environment Agency and other authoritative sources.
- 3.2.5. The soil testing results have been screened against GAC protective of a commercial / industrial end use at 1% soil organic matter (SOM). These GAC have been selected as no site specific SOM testing was carried out as part of the Stage 2 GI and these represent a conservative screen with regards to SOM content. The ground conditions that were encountered generally comprised made ground of gravelly sand / sandy gravel and natural deposits of silty gravelly sand / silty sandy gravel. The chosen GAC are considered appropriate for this soil type.
- 3.2.6. The soil samples were obtained from isolated locations along the linear proposed route and the results have been screened as individual samples i.e. statistical assessment has not been carried out.
- 3.2.7. A spreadsheet detailing the human health risk assessment is included as part of this Technical Appendix as Annex B with drawings showing the locations of the identified exceedances also appended.

Results

- 3.2.8. The human health risk assessment identified the following human health exceedances as summarised in Table 4.

Table 3.1: Human health exceedances identified within proposed scheme

Analyte	Units	GAC	Location of exceedance (concentration)	Concentration	Relevant strata
Benzo(a)pyrene	µg/kg	14000	TPDS2065 at 1.0 m	24380	Made Ground
			BHDS2070A at 1.0 m	20195	Made Ground
TPH (Aliphatics >C12-C16)	mg/kg	24	TPDS2065 at 1.0 m	45	Made Ground
			BHDS2075 at 1.0 m	150	Possible Made Ground
			BHDS2070A at 1.0 m	129	Made Ground
TPH (Aromatics >C12-C16)	mg/kg	169	TPDS2065 at 1.0 m	179	Made Ground

- 3.2.9. Benzo(a)pyrene, TPH aliphatic (C12 to C16) and TPH aromatic (C12 to C16) were all identified in exceedance of the human health GAC within TPDS2065 at 1.0m. The log for this exploratory hole identified the tested material as brown/black sandy slightly silty gravel with asphalt and ash material and a strong hydrocarbon odour. This trial pit was located at approximate chainage 3800 and was not targeted at a former land use.
- 3.2.10. Further benzo(a)pyrene and aliphatic TPH (C12 to C16) exceedances were identified in BHDS2070A at 1.0 m. This material was logged as dark brown sandy slightly silty gravel with fragments of tarmac and a slight hydrocarbon odour. This borehole was located at approximate chainage 4700 and was not targeted at a former land use.

- 3.2.11. A further aliphatic TPH (C12 to C16) exceedance was identified in BHDS2075 at 1.0 m relating to a brown very gravelly silty sand. This material did not show evidence of contamination with anthropogenic materials and visual or olfactory evidence of contamination not noted. This borehole was located at approximate chainage 7200 and was located downgradient of a tank feature to target potential contamination associated with this source.
- 3.2.12. Sixty soil samples were tested for the presence of asbestos and no asbestos fibres were detected in the analysed soil samples. Possible asbestos pipe was noted in TPDS2065 at 1.1 to 1.2m although this was not confirmed through testing.

3.3. Water Environment Risk Assessment

Methodology

- 3.3.1. The Tier 1 PRA provided within the PSSR and the ground model provided in Chapter 10, Geology, Soils and Groundwater, identified both a superficial bedrock aquifer groundwater receptor and surface water receptors within the study area. Further details on these receptors is provided in Chapter 10, Geology, Soils and Groundwater. A risk assessment methodology was adopted to reflect these sensitive receptors.
- 3.3.2. Soil leachate testing was carried out on 27 samples as part of the Stage 2 GI. Soil leachate testing was scheduled to provide general coverage of the underlying deposits whilst focussing on locations where a potential pathway was present i.e. groundwater ingress had been noted at shallow depth and potential contamination sources had been identified.
- 3.3.3. A single round of groundwater and surface water sampling was also undertaken to inform the water environment risk assessment. Eighteen groundwater samples and twelve surface water samples were collected during this work.

Groundwater Receptor

- 3.3.4. The Tier 2 GQRA to assess the risk to the groundwater receptor followed the guidance contained with SEPA document 'Assigning Groundwater Assessment Criteria for Pollutant Inputs', WAT-PS-10^{xii}.
- 3.3.5. Minimum Reporting Values (MRVs) provided by SEPA within this guidance have been used for the assessment of risk posed by hazardous substances. Where an MRV is not available, the Limit of Detection (LOD) provided by SEPA has been used; however, SEPA is currently developing these LODs and advises that LODs provided in the World Health Organisation (WHO) Guidelines for Drinking Water Quality^{xiii} should be used as a guide until formal LODs are determined.
- 3.3.6. Resource Protection Values (RPVs) summarised within the guidance have been used to assess the risk from non-hazardous substances. RPVs have been derived from the following sources.
- The Water Supply (Water Quality) (Scotland) Regulations 2001;
 - Drinking Water Directive 98/83/EC;
 - WHO Guidelines for Drinking Water Quality^{xiii}; and
 - US EPA National Primary Drinking Water Regulations.

Surface Water Receptor

- 3.3.7. SEPA Guidance Document WAT-SG-53^{xiv} provides Environmental Quality Standards (EQSs) for a range of priority (hazardous) substances and non-hazardous substances. These are taken from the standards provided within The Scotland River Basin District Directions. The freshwater EQSs provided in WAT-SG-53 and the Directions have been used as appropriate assessment limits to assess the risk to surface waters receptors within the study area. Where a statutory EQS was not available, non-statutory EQSs, which are also provided in WAT-SG-53, have been used where appropriate.
- 3.3.8. A spreadsheet detailing the water environment risk assessment is included as part of this Technical Appendices as Annex C, D and E. Drawings showing the locations of the identified exceedances are also appended.

Water Environment Risk Assessment Results

Soil Leachate Assessment

- 3.3.9. Analysis of the 27 soil leachate samples was undertaken using the methodology provided above and the subsequent assessment of these identified exceedances as summarised in Table 5.

Table 3.2: Summary of Soil Leachate Exceedances

Contaminant	Units	EQS	Location(s) of Exceedance(s) (surface water receptor)	RPV / MRV	Location(s) of Exceedance(s) (groundwater receptor)	Maximum Concentration
Cyanide	mg/l	0.001	BHDS2050 at 0.20 m, BHDS2011 at 0.50m, BHDS2050 at 0.50m, TPDS2066 at 0.50m, BHDS2021A at 0.50m, TPDS2072 at 0.50m, BHDS2077 at 1.0m	0.05	BHDS2050 at 0.20m	0.13
Cadmium	µg/l	0.08	TPDS2012 at 0.50m, BHDS2050 at 0.50m, TPDS2025 at 0.3m	5	None	0.17
Mercury	µg/l	0.05	BHDS2021 at 0.50m, BHDS2028 at 1.0m, TPDS2020 at 0.50m, TPDS2014 at 0.5m, BHDS2070A at 1.0m,	1	None	0.15

Contaminant	Units	EQS	Location(s) of Exceedance(s) (surface water receptor)	RPV / MRV	Location(s) of Exceedance(s) (groundwater receptor)	Maximum Concentration
			BHDS2087 at 0.50m			
Copper	µg/l	1	BHDS2011 at 0.50m, BHDS2021A at 0.50m, TPDS2074 at 0.50m, BHDS2014B at 1.50m, TPDS2020 at 0.50m, TPDS2039 at 3.3m, TPDS2072 at 0.50m, BHDS2046 at 0.50m, TPDS2014 at 0.50m, TPDS2022 at 0.50m, TPDS2040 at 0.50m, BHDS2077 at 1.0m	2000	None	8.68
Iron	µg/l	1000	None	200	BHDS2050 at 0.20m, BHDS2013 at 0.20m, BHDS2028 at 0.50m, BHDS2028 at 1.0m, BH2052 at 0.50m, BHDS2050 at 0.50m, TPDS2014 at 0.50m.	846
Anthracene	ng/l	100	BHDS2070A at 1.0m,	N/A	N/A	656
Fluoranthene	ng/l	6.3	TPDS2025 at 0.30m, TPDS2011 at 0.50m, BHDS2077 at 1.0m, BHDS2070A at 1.0m	N/A	N/A	1353
Benzo (b) fluoranthene	ng/l	0.17	TPDS2011 at 0.50m, BHDS2070A at 1.0m	100	None	82
Benzo (a) pyrene	ng/l	0.17	TPDS2011 at 0.50m,	10	TPDS2011 at 0.50m,	101

Contaminant	Units	EQS	Location(s) of Exceedance(s) (surface water receptor)	RPV / MRV	Location(s) of Exceedance(s) (groundwater receptor)	Maximum Concentration
			BHDS2070A at 1.0m		BHDS2070A at 1.0m	
Indeno (1,2,3 - cd) pyrene	ng/l	0.17	TPDS2025 at 0.30m, TPDS2011 at 0.50m, BHDS2070A at 1.0m	100	None	33
Benzo (ghi) perylene	ng/l	0.17	TPDS2025 at 0.30m, TPDS2011 at 0.50m, BHDS2070A at 1.0m	100	None	46
TPH (Aliphatics >C16-C21)*	µg/l	N/A	N/A	10	TPDS2077 at 0.50m, TPDS2022 at 0.50m	12
TPH (Aliphatics >C21-C35)*	µg/l	N/A	N/A	10	TPDS2077 at 0.50m, TPDS2025 at 0.30m, TPDS2022 at 0.50m	13
TPH (Aromatics >C16-C21)*	µg/l	N/A	N/A	10	BHDS2077 at 1.0m	26
TPH (Aromatics >C21-C35)*	µg/l	N/A	N/A	10	TPDS2025 at 0.30m, BHDS2077 at 1.0m, BHDS2070A at 1.0m	30

* No current drinking water standard is available for TPHs. Based on the potential risk posed by these compounds they have been screened against revoked UK drinking water standards (The Water Supply (Water Quality) Regulations 1989).

BOLD = location of maximum concentration.

- 3.3.10. The risk assessment indicated that leachable cyanide, metals, PAH and TPH within the soil potentially posed a risk to both groundwater and surface water receptors. The majority of the exceedances related to natural materials or reworked natural materials. The exceedances relating to cyanide and metals were generally marginal with the related materials showing no obvious visual or olfactory source for these contaminants. It should be noted that the assessment criteria for cyanide relates to free cyanide (hydrogen cyanide) whereas leachate results related only to total cyanide and so the use of the selected EQS and RPV represents a conservative approach for this contaminant.
- 3.3.11. The recorded PAH exceedances also generally related to natural or reworked natural material although the material associated with the exceedance in BHDS2070A at 1.0m was found to contain fragments of tarmac which is likely to represent the source of the

elevated concentrations of PAH. A slight hydrocarbon odour was also noted within this material.

- 3.3.12. Elevated concentrations of aromatic TPH C21-C35 were also identified at BHDS2070A at 1.0m with further TPH exceedances noted within three additional exploratory holes. These additional exceedances were associated with materials that did not show visual or olfactory evidence of hydrocarbons.

Groundwater Assessment

- 3.3.13. A single round of groundwater sampling was undertaken in June 2017 and 18 samples were retrieved during this work. The assessment of these samples identified exceedances as summarised in Table 6.

Table 3.3: Summary of Groundwater Exceedances

Contaminant	Units	EQS	Number of Exceedance(s) (surface water receptor)	RPV / MRV	Number of Exceedance(s) (groundwater receptor)	Maximum Concentration
Chloride	mg/l	250	2/18 (BHDS2061)	250	2/18 (BHDS2061)	1034
Nitrate	mg/l	18	10/18 (BHDS2055)	50	4/18 (BHDS2055)	74
Ammoniacal nitrogen	mg/l	0.5	18/18 (BHDS2045)	0.5	18/18 (BHDS2045)	4.20
Arsenic	µg/l	50	2/18 (BHDS2061)	10	12/18 (BHDS2061)	357.60
Cadmium	µg/l	0.08	7/18 (BHDS2043)	5	None	0.32
Mercury	µg/l	0.05	4/18 (BHDS2028)	1	None	0.23
Barium	µg/l	N/A	N/A	0.7	18/18 (BHDS2061)	493
Iron	µg/l	1000	1/18 (BHDS2075)	200	2/18 (BHDS2075)	1355
Zinc	µg/l	10.9	1/18 (BHDS2045)	5000	None	19.58
Aluminium	µg/l	15	5/18 (BHDS2057)	200	1/18 (BHDS2057)	1099
Manganese	µg/l	123	3/18 (BHDS2059)	50	11/18 (BHDS2059)	462
Chromium VI	mg/l	0.0034	1/18 (BHDS2028)	N/A	N/A	0.04
TPH (Aliphatics >C10-C12)*	µg/l	N/A	N/A	10	1/18 (BHDS2043)	13
TPH (Aliphatics >C12-C16)*	µg/l	N/A	N/A	10	12/18 (BHDS2043)	58

Contaminant	Units	EQS	Number of Exceedance(s) (surface water receptor)	RPV / MRV	Number of Exceedance(s) (groundwater receptor)	Maximum Concentration
TPH (Aliphatics >C16-C21)*	µg/l	N/A	N/A	10	16/18 (BHDS2043)	49
TPH (Aliphatics >C21-C35)*	µg/l	N/A	N/A	10	16/18 (BHDS2010)	1973
TPH (Aliphatics >C35-C40)*	µg/l	N/A	N/A	10	2/18 (BHDS2010)	185
TPH (Aromatics >C12-C16)*	µg/l	N/A	N/A	10	12/18 (BHDS2043)	23
TPH (Aromatics >C16-C21)*	µg/l	N/A	N/A	10	11/18 (BHDS2043)	21
TPH (Aromatics >C21-C35)*	µg/l	N/A	N/A	10	5/18 (BHDS2010)	530
TPH (Aromatics >C35-C40)*	µg/l	N/A	N/A	10	1/18 (BHDS2010)	62

* No current drinking water standard is available for TPHs. Based on the potential risk posed by these compounds they have been screened against revoked UK drinking water standards (The Water Supply (Water Quality) Regulations 1989).

Location of maximum concentration shown in brackets.

BOLD = Soil leachate assessment also indicated that contaminant posed a risk to receptors

- 3.3.14. The risk assessment indicated that metals and TPH within the assessed groundwater samples potentially posed a risk to both groundwater and surface water receptors. The materials encountered during the drilling of the monitored boreholes generally comprised only natural materials or made ground comprising reworked natural material and so it is likely that the metals exceedances relate to background concentrations of these substances. Man-made components such as ash, clinker and slag may also represent the sources of the elevated metals concentrations; however, such materials were only identified at one location (TPDS2065 at 0.8 m to 1.7 m).
- 3.3.15. The only monitoring well that exhibited anthropogenic constituents within its screened materials was BHDS2070A containing tarmac and a slight hydrocarbon odour. Borehole BHDS2070A was one of only two monitoring wells where aliphatic TPH was not detected within the groundwater but the range of aromatic TPH fractions were similar to those identified in groundwater in other boreholes. The highest concentrations of TPH were identified in BHDS2010 where no made ground was identified, and BHDS2043 where only reworked natural material was identified.
- 3.3.16. Elevated concentrations of cyanide were identified in the groundwater samples; however, all results for free cyanide, to which the GAC for cyanide relates, were below detectable limits with only total cyanide showing identifiable concentrations. On this basis, cyanide has not been considered to represent a risk.

- 3.3.17. Whilst the concentrations of some contaminants were found to pose a risk to surface water and groundwater receptors, the results indicate that these are unlikely to be related to obvious sources of contamination identified during the GI.

Surface Water Assessment

- 3.3.18. One round of surface water samples was taken from twelve waterbodies within the study area during the Stage 2 GI. These were assessed against EQS values following the methodology detailed above to investigate the water quality at these locations and to quantify the level of risk posed by the identified pollutant linkages. An assessment of the risk posed to the groundwater receptor has not been carried out as no relevant source-pathway-receptor linkage is present. A summary of the identified EQS exceedances are provided in Table 7.

Table 3.4: Summary of Surface Water Exceedances

Contaminant	Units	EQS	Number of Exceedance(s) (surface water receptor)	Maximum Concentration
Mercury	µg/l	0.05	5/12 (Dulnain West)	0.17
Copper	µg/l	1	3/12 (Allt Na Fherna East)	2.27
Aluminium	µg/l	15	10/12 (Loch Alvie)	26

Location of maximum concentration shown in brackets.

BOLD = Soil leachate and groundwater assessments indicated that contaminant posed a risk to receptors

Water Environment Risk Assessment Discussion

- 3.3.19. The following Table 8 summarises the chemical constituents found to be in exceedance of the appropriate GAC within the soil leachates, groundwater and surface water samples. Where concentrations are greater than the GACs within the soil leachates, and the groundwater and / or surface water this may indicate that a potential pollutant linkage exists. Discussion is provided in Table 8 about the likelihood of a pollutant linkage being present.

Table 3.5: Discussion of Exceedances of EQS and RPV/MRVs

Contaminant	Soil Leachate Exceedance (Y/N)	Groundwater Exceedance (Y/N)	Surface Water Exceedance (Y/N)	Comments
Chloride	N	Y	N	Exceedances were only identified in the groundwater samples and based on the available chemical results this indicates an off-site or background source.
Nitrate	**	Y	N/A	Analysis for this contaminant was not carried out on the soil leachates but an obvious source for the elevated concentrations in the groundwater was not identified during the GI and this indicates an offsite source likely due to the agricultural use of the surrounding land.



Contaminant	Soil Leachate Exceedance (Y/N)	Groundwater Exceedance (Y/N)	Surface Water Exceedance (Y/N)	Comments
Ammoniacal Nitrogen	N	Y	N	Exceedances were only identified in the groundwater samples and based on the available chemical results this indicates an off-site source and likely due to the agricultural use of the surrounding land.
Arsenic	N	Y	N	Exceedances were only identified in the groundwater samples and based on the available chemical results this indicates an off-site or background source.
Cyanide	Y*	N	N	<p>Free cyanide analysis was not carried out on the soil leachate samples and so a conservative approach was taken whereby the available results for total cyanide were assessed against EQS and RPVs for free cyanide. Concentrations of total cyanide were greater than the assessment criteria within the leachates.</p> <p>Free cyanide analysis carried out on groundwater and surface water samples did not detect this contaminant and this indicates that a pollutant linkage does not exist. However, it should be noted that the assessment criteria for free cyanide (0.001 mg/l) is less than the laboratory LOD (0.05 mg/l).</p>
Cadmium	Y	Y	N	Soil leachate and groundwater exceedances were identified for this contaminant. An obvious source for this contaminant was generally absent within the underlying soil materials and so it is considered that the recorded concentrations reflect background concentrations. Similar exceedances were not identified in the surface water test results.
Mercury	Y	Y	Y	Soil leachate and groundwater exceedances were identified for this contaminant. An obvious source for this

Contaminant	Soil Leachate Exceedance (Y/N)	Groundwater Exceedance (Y/N)	Surface Water Exceedance (Y/N)	Comments
				contaminant was generally absent within the underlying soil materials and so it is considered that the recorded concentrations reflect background concentrations.
Barium	**	Y	N/A	Analysis for this contaminant was not carried out on the soil leachates but an obvious source for the elevated concentrations in the groundwater was not identified during the GI and this indicates an offsite or background source.
Copper	Y	N	Y	Soil leachate exceedances were identified for this bioavailable copper; however, when groundwater concentrations were adjusted for bioavailable copper no exceedances were identified within the groundwater indicating no pollutant linkage. An obvious source for this contaminant was generally absent within the underlying soil materials and so it is considered that the recorded concentrations reflect background concentrations. Some surface water exceedances for bioavailable copper were also identified although there was no evidence that these were attributable to made ground associated with the proposed scheme.
Iron	Y	Y	N	Soil leachate and groundwater exceedances were identified for this contaminant. An obvious source for this contaminant was generally absent within the underlying soil materials and so it is considered that the recorded concentrations reflect background concentrations. Similar exceedances were not identified in the surface water test results.
Zinc	N	Y	N	Exceedances were only identified in the groundwater



Contaminant	Soil Leachate Exceedance (Y/N)	Groundwater Exceedance (Y/N)	Surface Water Exceedance (Y/N)	Comments
				samples and based on the available chemical results this indicates an off-site or background source.
Aluminium	**	Y	Y	Analysis for this contaminant was not carried out on the soil leachates but an obvious source for the elevated concentrations in the groundwater and surface water was not identified during the GI and this indicates an offsite or background source.
Manganese	N	Y	N/A	Exceedances were only identified in the groundwater samples and based on the available chemical results this indicates an off-site or background source.
Chromium VI	**	Y	N	It should be noted that the EQS for hexavalent chromium (0.0034 mg/l) is less than the laboratory LOD (0.03 mg/l). Only a single, marginal exceedance was identified within the groundwater samples from BHDS2028. No made ground was identified at this location. Although offsite potential historical sources were identified nearby.
Anthracene	Y	N	N	Whilst soil leachate exceedances were identified for this contaminant similar exceedances were not identified in the groundwater or surface water test results i.e. based on the available information there is no evidence that a pollutant linkage exists.
Fluoranthene	Y	N	N	
Benzo (b) fluoranthene	Y	N	N	
Benzo (a) pyrene	Y	N	N	
Indeno (1,2,3 - cd) pyrene	Y	N	N	
Benzo (ghi) perylene	Y	N	N	
TPH (Aliphatics >C16-C21)	Y	Y	N/A	Only 2 out of 27 sample locations were found to have detectable but relatively marginal soil leachate concentrations of this contaminant. Conversely, elevated groundwater concentrations of this contaminant were widespread. Only very isolated occurrences of materials showing visual or



Contaminant	Soil Leachate Exceedance (Y/N)	Groundwater Exceedance (Y/N)	Surface Water Exceedance (Y/N)	Comments
				olfactory evidence of this contaminant were identified during the GI and based on this it is considered highly unlikely that there is an onsite source for the observed groundwater contamination and that an offsite or background source is present.
TPH (Aliphatics >C21-C35)	Y	Y	N/A	Only 3 out of 27 sample locations were found to have detectable but relatively marginal soil leachate concentrations of this contaminant. Conversely, elevated groundwater concentrations of this contaminant were widespread. Only very isolated occurrences of materials showing visual or olfactory evidence of this contaminant were identified during the GI and based on this it is considered highly unlikely that there is an onsite source for the observed groundwater contamination and that an offsite or background source is present.
TPH (Aliphatics >C35-C40)	N	Y	N/A	Exceedances were only identified in the groundwater samples and based on the available chemical results this indicates an off-site or background source.
TPH (Aromatics >C16-C21)	Y	Y	N/A	Only 1 out of 27 sample locations was found to have detectable but relatively marginal soil leachate concentrations of this contaminant. Conversely, elevated groundwater concentrations of this contaminant were widespread. Only very isolated occurrences of materials showing visual or olfactory evidence of this contaminant were identified during the GI and based on this it is considered highly unlikely that there is an onsite source for the observed groundwater contamination and that an offsite source or background is present.

Contaminant	Soil Leachate Exceedance (Y/N)	Groundwater Exceedance (Y/N)	Surface Water Exceedance (Y/N)	Comments
TPH (Aromatics >C21-C35)	Y	Y	N/A	Only 3 out of 27 sample locations were found to have detectable but relatively marginal soil leachate concentrations of this contaminant. Conversely, elevated groundwater concentrations of this contaminant were widespread. Only very isolated occurrences of materials showing visual or olfactory evidence of this contaminant were identified during the GI and based on this it is considered highly unlikely that there is an onsite source for the observed groundwater contamination and that an offsite or background source is present.
TPH (Aromatics >C35-C40)	N	Y	N/A	Exceedances were only identified in the groundwater samples and based on the available chemical results this indicates an off-site or background source.

* No free cyanide analysis carried out. Assessment based on total cyanide concentrations.

** Relevant analysis not carried out

N/A EQS not available

3.4. Phytotoxicity Risk Assessment

- 3.4.1. The soil results were also screened with regards to their associated phytotoxic risk. The screening values used were based on the pH value of each individual soil sample and were derived from relevant criteria taken from the MAFF Code of Practice^{xv}. A summary of the assessment is provided in Annex F.
- 3.4.2. No exceedances of the screening criteria were identified; however, these criteria are based on pH ranges of between pH 5.0 and pH >7 and pH readings of less than pH 5.0 were recorded at BHDS2028, TPDS2059, TPDS2060, TPDS2072, BHDS2046, TPDS022, BHDS2069, BHDS2079 and BHDS2075 at depths of between 0.3m bgl and 2.1 m bgl. As metals are more available in acidic soils it is considered that the screening criteria may not be sufficiently protective at these locations and a phytotoxic risk is possible.
- 3.4.3. The spreadsheet detailing the phytotoxicity risk assessment is included as part of this Technical Appendix within Annex F.

3.5. Ground Gas Risk Assessment

- 3.5.1. The design for the Proposed Scheme does not incorporate enclosed spaces and it is unlikely that the scheme will create pathways that will allow ground gas to migrate to the isolated residential properties located close to the A9. However, five rounds of gas monitoring were carried out from selected monitoring wells between 29th May and 3rd September 2017 and the results were assessed to identify the level of risk posed by the identified gas levels. Given the lack of pollutant linkage these risk levels are for information only. Note also the limitations identified in the main Geology and Soils chapter. The risk assessment followed the procedures prescribed in CIRIA guidance document C665^{xvi}.
- 3.5.2. Measurements of the concentration of methane, carbon dioxide, oxygen, carbon monoxide and hydrogen sulphide were taken in addition to a measurement of gas flow rate.
- 3.5.3. The ground gas risk assessment initially comprised a Level 1 assessment which consisted of a preliminary screening of gas concentrations against threshold concentrations provided by BS8485:2015^{xvii} and CIRIA C665. For this preliminary exercise, the gas monitoring data was assessed against a 1% threshold for methane and a 5% threshold for carbon dioxide. The relevant Workplace Exposure Limits (WELs) as outlined within the Health and Safety Executive's (HSE) guidance document EH40/2005 (2011)^{xviii} were also adopted for the assessment. These WELs comprise a carbon monoxide long-term exposure limit of 30 parts per million (ppm) and 200ppm for a short-term exposure limit. For hydrogen sulphide, the long-term exposure limit of 5ppm and the short-term exposure limit of 10ppm were used for the assessment.
- 3.5.4. A maximum carbon dioxide concentration of 17% vol. was recorded in BHDS2032. Methane was only recorded at two locations (BHDS2054 and BHDS2080) with a maximum concentration of 1% vol. being measured at BHDS2054. Hydrogen sulphide and carbon monoxide were not recorded in any of the monitoring wells. A maximum flow rate of 26.21 l/hr was identified in borehole BHDS2069.
- 3.5.5. As the Level 1 assessment thresholds were exceeded at several locations for carbon dioxide and were equalled at one location for methane, a Level 2 assessment has been carried out with regards to these gases. For the Level 2 assessment gas screening values (GSVs) are calculated by multiplying borehole gas concentration (% v/v) by borehole flow rate (l/h). The GSVs were calculated using the following formula:
- $GSV = \text{Borehole flow rate (l/h)} \times \text{Gas concentration (\% v/v)} / 100$
- 3.5.6. Using the above formula and the maximum flow rate recorded in the relevant borehole, the calculated maximum GSV for carbon dioxide was 0.419 at BHDS2069 which relates to a CS2 low level of risk according to the relevant guidance. The recorded concentration of methane at BHDS2054 corresponded to a GSV of 0.0011 which relates to a CS1 very low level of risk.
- 3.5.7. Given the lack of fully enclosed spaced e.g. buildings associated with the proposed scheme and the lack of existing buildings in the immediate vicinity of the proposed scheme it is considered that a related pollutant linkage being formed is unlikely. Given the low level of risk and unlikely nature of the risk it is considered that the identified levels of gas are not problematic.

4. Recommendations

- 4.1.1. The available information did not indicate that unacceptable levels of contamination were present at the proposed scheme although some of the potential sources of contamination identified within the Tier 1 PRA were not fully investigated during the Stage 2 GI. Further investigation and assessment of unassessed potential pollutant linkages are to be carried out as part of the Stage 3 GI work which is currently underway. Information pertaining to the Stage 3 investigation was not available at the time of writing.

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- ⁱⁱⁱ Atkins Mouchel Joint Venture (AMJV). (2016). A9 Dualling Northern Section: Dalraddy to Slochd Geotechnical Preliminary Sources Study Report.
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- ^v Raeburn Drilling and Geotechnical Limited. (2017). A9 Dualling: Dalraddy to Slochd, Report on Stage 2 Preliminary Ground Investigation.
- ^{vi} Environment Agency. (2009). Human Health Toxicological Assessment of Contaminants in Soil (SR2).
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- ^{xii} Scottish Environment Protection Agency (SEPA). (2014) WAT-PS-10-01, Assigning Groundwater Assessment Criteria for Pollutant Inputs. Version 3. August 2014.
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- ^{xiv} Scottish Environment Protection Agency (SEPA). (2015). WAT-SG-53, Environmental Standards for Discharges to Surface Waters. Version 6. December 2015.
- ^{xv} Ministry of Agriculture, Fisheries and Food. (1998). Code of Good Agricultural Practice for Protection of Soil.
- ^{xvi} CIRIA C665. (2007). Assessing risks posed by hazardous ground gases. London 2007.
- ^{xvii} British Standards Institution. (2015). BS8485:2015: Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.
- ^{xviii} Health and Safety Executive (HSE). (2011). EH40/2005 Workplace exposure limits - Containing the list of workplace exposure limits for use with the Control of Substances Hazardous to Health Regulations (as amended). Second edition.

Annex A. Contaminated Land Constraint Drawings

Annex B. Human Health Risk Assessment

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
General Inorganics											
pH	pH Units	108	108	n/a	4	9.20	0	BHDS2040	2		N/A
Asbestos	N/A	60	0	n/a	n/a	n/a	0	N/A	N/A	present	N/A
Complex Cyanide		6	0	0.1	0.1	0.10	0	N/A	N/A	34	Atkins SSV
Total Cyanide	mg/kg	110	79	0.1	0.1	0.50	0	BHDS2057	0.5	34	Atkins SSV
Free Cyanide	mg/kg	106	0	0.1	0.1	0.10	0	N/A	N/A	34	Atkins SSV
Metals											
Arsenic	mg/kg	110	109	1	1	16.00	0	TPDS2039	4	640	Atkins SSV
Cadmium	mg/kg	110	2	1	1	2.00	0	TPDS2039	3.3	230	Atkins SSV
Chromium	mg/kg	110	110	1	3	130.00	0	BHDS2040	2	8840	LQM/ CIEH
Lead	mg/kg	110	110	1	4	49.00	0	TPDS2060	2.15	2300	C4SL
Mercury	mg/kg	110	0	1	1	1.00	0	N/A	N/A	3600	SSV (inorganic)
Selenium	mg/kg	110	0	1	1	1.00	0	N/A	N/A	13000	Atkins SSV
Copper	mg/kg	110	110	1	1	65.00	0	BHDS2072	0.3	71700	LQM/ CIEH
Nickel	mg/kg	110	109	1	1	51.00	0	BHDS2040	2	1800	Atkins SSV
Zinc	mg/kg	110	110	1	4	190.00	0	TPDS2060	2.15	665000	LQM/ CIEH
Vanadium	mg/kg	57	57	1	14	100.00	0	BHDS2065	0.5	7530	Atkins SSV
Hexavalent Chromium	mg/kg	72	8	0.3	0.3	0.60	0	BHDS2076	0.5	35	LQM/ CIEH

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
PAHs											
Naphthalene	µg/kg	111	4	10	10	12080.00	0	TPDS2065	1	76000	LQM/ CIEH
Acenaphthylene	µg/kg	111	7	10	10	1026.00	0	BHDS2070A	1	86000	LQM/ CIEH
Acenaphthene	µg/kg	111	5	10	10	20700.00	0	TPDS2065	1	57000	LQM/ CIEH
Fluorene	µg/kg	111	5	10	10	28400.00	0	TPDS2065	1	31000	LQM/ CIEH
Phenanthrene	µg/kg	111	11	10	10	106202.00	0	TPDS2065	1	22000000	LQM/ CIEH
Anthracene	µg/kg	111	6	10	10	35906.00	0	TPDS2065	1	53000000	LQM/ CIEH
Fluoranthene	µg/kg	111	15	10	10	85405.00	0	TPDS2065	1	23000000	LQM/ CIEH
Pyrene	µg/kg	111	13	10	10	58840.00	0	TPDS2065	1	54000000	LQM/ CIEH
Benzo (a) anthracene	µg/kg	111	13	10	10	34966.00	0	TPDS2065	1	90000	LQM/ CIEH
Chrysene	µg/kg	111	13	10	10	26932.00	0	TPDS2065	1	140000	LQM/ CIEH
Benzo (b) fluoranthene	µg/kg	111	12	10	10	27542.00	0	BHDS2070A	1	100000	LQM/ CIEH
Benzo (k) fluoranthene	µg/kg	111	8	10	10	20256.00	0	BHDS2070A	1	140000	LQM/ CIEH
Benzo (a) pyrene	µg/kg	111	13	10	10	24380.00	2	TPDS2065	1	14000	LQM/ CIEH

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Indeno (1,2,3 - cd) pyrene	µg/kg	111	10	10	10	15190.00	0	TPDS2065	1	60000	LQM/ CIEH
Dibenzo (ah) anthracene	µg/kg	111	6	10	10	4457.00	0	TPDS2065	1	13000	LQM/ CIEH
Benzo (ghi) perylene	µg/kg	111	9	10	10	12484.00	0	TPDS2065	1	650000	LQM/ CIEH
Total PAHs (USEPA 16)	µg/kg	111	11	10	10	50548.800	0	TPDS2065	1		N/A
BTEX											
Benzene	µg/kg	42	0	5	5	5.00	0	N/A	N/A	13100	Atkins SSV
Ethylbenzene	µg/kg	42	0	5	5	5.00	0	N/A	N/A	180000000	Atkins SSV
m & p - Xylene	µg/kg	42	0	10	10	10.00	0	N/A	N/A	276000000	Atkins SSV
o - Xylene	µg/kg	42	0	5	5	5.00	0	N/A	N/A	296000000	Atkins SSV
Toluene	µg/kg	42	0	5	5	5.00	0	N/A	N/A	414000000	Atkins SSV
MTBE	µg/kg	42	0	5	5	5.00	0	N/A	N/A	3340000	Atkins SSV
Aliphatics											
TPH (Aliphatics C5-C6)	µg/kg	111	0	10	10	10.00	0	N/A	N/A	304000	LQM/ CIEH
TPH (Aliphatics C6-C8)	µg/kg	111	2	10	10	14.00	0	BHDS2023	0.2	144000	LQM/ CIEH
TPH (Aliphatics C8-C10)	mg/kg	111	1	1	1	1.00	0	BHDS2015	0.5	78000	LQM/ CIEH
TPH (Aliphatics >C10-C12)	mg/kg	111	6	1	1	5.00	0	TPDS2065	1	48	LQM/ CIEH
TPH (Aliphatics >C12-C16)	mg/kg	111	21	1	1	150.00	3	BHDS2075	1	24	LQM/ CIEH

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
TPH (Aliphatics >C16-C21)	mg/kg	111	78	1	1	441.00	0	BHDS2075	1	1600000	LQM/ CIEH
TPH (Aliphatics >C21-C35)	mg/kg	111	49	1	1	900.00	0	BHDS2070A	1	1600000	LQM/ CIEH
TPH (Aliphatics >C35-C40)	mg/kg	111	29	1	1	87.00	0	TPDS2065	1		N/A
Aromatics											
TPH (Aromatics C6-C7)	µg/kg	111	0	10	10	10.00	0	N/A	N/A	1220000	LQM/ CIEH
TPH (Aromatics C7-C8)	µg/kg	111	0	10	10	10.00	0	N/A	N/A	869000	LQM/ CIEH
TPH (Aromatics C8-C10)	µg/kg	111	2	10	10	11.00	0	BHDS2078	1	613000	LQM/ CIEH
TPH (Aromatics >C10-C12)	mg/kg	111	32	1	1	28.00	0	TPDS2065	1	364	LQM/ CIEH
TPH (Aromatics >C12-C16)	mg/kg	111	48	1	1	179.00	1	TPDS2065	1	169	LQM/ CIEH
TPH (Aromatics >C16-C21)	mg/kg	111	90	1	1	393.00	0	TPDS2065	1	28000	LQM/ CIEH
TPH (Aromatics >C21-C35)	mg/kg	111	45	1	1	2563.00	0	TPDS2065	1	28000	LQM/ CIEH
TPH (Aromatics >C35-C40)	mg/kg	111	40	1	1	299.00	0	TPDS2065	1		N/A
Phenols											
Phenol	ug/kg	12	0	100	100	100.00	0	N/A	N/A	686000	Atkins SSV
2 - Chlorophenol	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
2 - Methylphenol	ug/kg	12	0	100	100	100.00	0	N/A	N/A	187000000	Atkins SSV

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
4 - Methylphenol	ug/kg	12	0	100	100	100.00	0	N/A	N/A	185000000	Atkins SSV
2 - Nitrophenol	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
2,4 - Dimethylphenol	ug/kg	12	0	100	100	100.00	0	N/A	N/A	35600000	Atkins SSV
2,4 - Dichlorophenol	ug/kg	12	0	500	500	500.00	0	N/A	N/A		N/A
4 - Chloro - 3 - Methylphenol	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
2,4,6 - Trichlorophenol	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
2,4,5 - Trichlorophenol	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
2,4 - Dinitrophenol	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
4 - Nitrophenol	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Pentachlorophenol	ug/kg	12	0	80	80	80.00	0	N/A	N/A		N/A
Naphthalene	ug/kg	12	0	100	100	100.00	0	N/A	N/A	76000	LQM/ CIEH
Acenaphthylene	ug/kg	12	0	100	100	100.00	0	N/A	N/A	86000	LQM/ CIEH
Acenaphthene	ug/kg	12	0	100	100	100.00	0	N/A	N/A	57000	LQM/ CIEH
Fluorene	ug/kg	12	0	100	100	100.00	0	N/A	N/A	31000	LQM/ CIEH
Phenanthrene	ug/kg	12	1	100	100	2207.0 0	0	TPDS2065	0.8	22000000	LQM/ CIEH
Anthracene	ug/kg	12	0	100	100	100.00	0	N/A	N/A	530000000	LQM/ CIEH
Fluoranthene	ug/kg	12	1	100	100	4358.0 0	0	TPDS2065	0.8	23000000	LQM/ CIEH
Pyrene	ug/kg	12	1	100	100	3514.0 0	0	TPDS2065	0.8	54000000	LQM/ CIEH

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Benzo (a) anthracene	ug/kg	12	0	100	100	100.00	0	N/A	N/A	90000	LQM/ CIEH
Chrysene	ug/kg	12	1	100	100	2242.00	0	TPDS2065	0.8	140000	LQM/ CIEH
Benzo (b) fluoranthene	ug/kg	12	1	100	100	2107.00	0	TPDS2065	0.8	100000	LQM/ CIEH
Benzo (k) fluoranthene	ug/kg	12	1	100	100	2530.00	0	TPDS2065	0.8	140000	LQM/ CIEH
Benzo (a) pyrene	ug/kg	12	1	100	100	2105.00	0	TPDS2065	0.8	14000	LQM/ CIEH
Indeno (1,2,3 - cd) pyrene	ug/kg	12	1	100	100	2698.00	0	TPDS2065	0.8	60000	LQM/ CIEH
Dibenzo (ah) anthracene	ug/kg	12	0	100	100	100.00	0	N/A	N/A	13000	LQM/ CIEH
Benzo (ghi) perylene	ug/kg	12	1	100	100	3378.00	0	TPDS2065	0.8	650000	LQM/ CIEH
2 - Methylanthalene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
2 - Chloronaphthalene	ug/kg	12	0	100	100	100.00	0	N/A	N/A	60200000	Atkins SSV
1,3 - Dichlorobenzene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
1,4 - Dichlorobenzene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
1,2 - Dichlorobenzene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Nitrobenzene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
1,3,5 - Trichlorobenzene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
1,2,4 - Trichlorobenzene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
1,2,3 - Trichlorobenzene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Pentachlorobenzene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Azobenzene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Hexachlorobenzene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Dimethyl phthalate	ug/kg	12	0	500	500	500.00	0	N/A	N/A		N/A
Diethyl phthalate	ug/kg	12	0	500	500	500.00	0	N/A	N/A	14000	EIC/AGS/CL:AIRE
Di-n-butyl phthalate	ug/kg	12	0	200	200	200.00	0	N/A	N/A	15400000	Atkins SSV
Butyl benzyl phthalate	ug/kg	12	0	500	500	500.00	0	N/A	N/A	941000000	Atkins SSV
bis (2 - ethylhexyl) phthalate	ug/kg	12	0	1000	1000	1000.00	0	N/A	N/A	85000000	EIC/AGS/CL:AIRE
Di - n - octyl phthalate	ug/kg	12	0	500	500	500.00	0	N/A	N/A	89100000	Atkins SSV
Aniline	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
bis (2 - chloroethyl) ether	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Benzyl alcohol	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Hexachloroethane	ug/kg	12	0	100	100	100.00	0	N/A	N/A	510000	Atkins SSV

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
n - Nitrosodi - n - Propylamine	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Isophorone	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
bis (2 - chloroethoxy) methane	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
4 - Chloroaniline	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Hexachlorobutadiene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Hexachlorocyclopentadiene	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
2 - Nitroaniline	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
3 - Nitroaniline	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
4 - Nitroaniline	ug/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
2,6 - Dinitrotoluene	µg/kg	12	0	100	100	100.00	0	N/A	N/A	1850000	Atkins SSV
Dibenzofuran	µg/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
2,4 - Dinitrotoluene	µg/kg	12	0	150	150	150.00	0	N/A	N/A	3740000	Atkins SSV
4 - Chlorophenyl phenyl ether	µg/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Diphenylamine	µg/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
4 - Bromophenylphenyl ether	µg/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
Carbazole	µg/kg	12	0	100	100	100.00	0	N/A	N/A		N/A
1,1,1,2 - Tetrachloroethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A	120000	LQM/ CIEH

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
1,1,1 - Trichloroethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A	700000	LQM/ CIEH
1,1,2,2 - Tetrachloroethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A	290000	LQM/ CIEH
1,1,2 - Trichloroethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A	42500	Atkins SSV
1,1 - Dichloroethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A	122000	Atkins SSV
1,1 - Dichloroethene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	12600	Atkins SSV
1,1 - Dichloropropene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
1,2,3 - Trichloropropane	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
1,2,4 - Trimethylbenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	175000	Atkins SSV
1,2 - Dibromoethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
1,2 - Dichlorobenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
1,2 - Dichloroethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
1,2 - Dichloropropane	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
1,3,5 - Trimethylbenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
1,3 - Dichlorobenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
1,3 - Dichloropropane	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
1,4 - Dichlorobenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
2,2 - Dichloropropane	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
2 - Chlorotoluene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
4 - Chlorotoluene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
4 - Isopropyltoluene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
Benzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	13100	Atkins SSV
Bromobenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	44700	Atkins SSV
Bromochloromethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A	907	Atkins SSV
Bromodichloromethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
Bromoform	ug/kg	12	0	5	5	5.00	0	N/A	N/A	347000	Atkins SSV
Bromomethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
Carbon tetrachloride	ug/kg	12	0	5	5	5.00	0	N/A	N/A	3000	LQM/ CIEH
Chlorobenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	59000	LQM/ CIEH
Chloroethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A	463000	Atkins SSV
Chloroform	ug/kg	12	0	5	5	5.00	0	N/A	N/A	48000	Atkins SSV
Chloromethane	ug/kg	12	1	5	5	23.00	0	BHDS2050	0.2	480	Atkins SSV
cis 1,2 - Dichloroethene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	14000	EIC/AGS/CL :AIRE

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
cis 1,3 - Dichloropropene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
Dibromochloromethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A	9830	Atkins SSV
Dibromomethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
Dichlorodifluoromethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
Ethylbenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	180000000	Atkins SSV
iso - Propylbenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	180000000	Atkins SSV
m & p - Xylene	ug/kg	12	0	10	10	10.00	0	N/A	N/A	276000000	Atkins SSV
Methylene chloride (Dichloromethane)	ug/kg	12	0	50	50	50.00	0	N/A	N/A		N/A
n - Butylbenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
n - Propylbenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
o - Xylene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	296000000	Atkins SSV
sec - Butylbenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
Styrene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	626000	EIC/AGS/CL:AIRE
tert - Butylbenzene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
Tetrachloroethene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	130000	LQM/ CIEH
Toluene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	414000000	Atkins SSV
Trans - 1,2 - Dichloroethene	ug/kg	12	0	5	5	5.00	0	N/A	N/A	22000	EIC/AGS/CL:AIRE
Trans - 1,3 - Dichloropropene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Trichloroethene	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
Trichlorofluoromethane	ug/kg	12	0	5	5	5.00	0	N/A	N/A		N/A
Vinyl chloride	ug/kg	12	0	5	5	5.00	0	N/A	N/A	63	LQM/ CIEH
PCB Congener 81	ug/kg	15	0	0.5	0.5	0.50	0	N/A	N/A		N/A
PCB Congener 77	ug/kg	15	0	0.5	0.5	0.50	0	N/A	N/A		N/A
PCB Congener 123	ug/kg	15	0	0.5	0.5	0.50	0	N/A	N/A		N/A
PCB Congener 118	ug/kg	15	0	0.5	0.5	0.50	0	N/A	N/A		N/A
PCB Congener 114	ug/kg	15	0	0.5	0.5	0.50	0	N/A	N/A		N/A
PCB Congener 105	ug/kg	15	0	0.5	0.5	0.50	0	N/A	N/A		N/A
PCB Congener 126	ug/kg	15	0	0.5	0.5	0.50	0	N/A	N/A		N/A
PCB Congener 167	ug/kg	15	0	0.5	0.5	0.50	0	N/A	N/A		N/A
PCB Congener 156	ug/kg	15	0	0.5	0.5	0.50	0	N/A	N/A		N/A
PCB Congener 157	ug/kg	15	0	0.5	0.5	0.50	0	N/A	N/A		N/A
PCB Congener 169	ug/kg	15	0	0.5	0.5	0.50	0	N/A	N/A		N/A
PCB Congener 189	ug/kg	15	0	0.7	0.7	0.70	0	N/A	N/A		N/A
Total 12 PCB Congeners	ug/kg	15	0	6	6	6.00	0	N/A	N/A		N/A

Annex C. Water Environment Risk Assessment – Soil Leachates

C.1. EQS Screening

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
General Inorganics											
Boron	mg/l	27	6	0.3	0.3	0.40	0	TPDS2072	0.5	2	wat-sg-53
Total Cyanide	mg/l	27	7	0.01	0.01	0.13	7	BHDS2050	0.2	0.001	RBDD
Chloride	mg/l	27	10	4	4	50.00	0	TPDS2074	0.5	250	wat-sg-53
Ammoniacal Nitrogen	mg/l	27	26	0.1	0.1	2.50	17	BHDS2070A	1	0.5	WAT-SG-53 (most conservative - ammonia)
Sulphate (as SO ₄)	mg/l	27	9	4	4	55.00	0	BHDS2070A	1	400	wat-sg-53
Sulphide	mg/l	27	0	0.01	0.01	0.01	0	N/A	N/A	0.01	LOD
pH	pH units	27	27	-	4.6	8.10	0	TPDS2074	0.5	9	N/A
Dissolved Organic Carbon	mg/l	27	27	1	2	49.00	27	BHDS2028	0.5	1	LOD
Metals											
Arsenic	ug/l	27	12	0.2	0.2	1.90	0	TPDS2074	0.5	50	RBDD
Cadmium	ug/l	27	10	0.04	0.04	0.17	3	TPDS2012	0.5	0.08	RBDD
Chromium	ug/l	27	27	0.04	0.14	3.60	0	BHDS2070A	1	4.7	RBDD
Lead	ug/l	27	27	0.01	0.04	1.94	2	TPDS2014	0.5	1.2	RBDD
Mercury	ug/l	27	11	0.08	0.08	0.15	6	BHDS2087	0.5	0.05	RBDD

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Selenium	ug/l	27	15	0.5	0.5	2.18	13	BH2052	0.5	0.5	LOD
Copper	ug/l	27	27	0.03	0.1388452	8.68	12	BHDS2011	0.5	1	RBDD
Nickel	ug/l	27	27	0.3	0.0320035	0.40	0	TPDS2074	0.5	20	RBDD
Zinc	ug/l	27	27	0.3	0.3928633	7.84	0	TPDS2072	0.5	10.9	RBDD
Calcium	ug/l	27	27	1	189	4711.00	27	TPDS2074	0.5	1	LOD
Magnesium	ug/l	27	27	1	88	1000.00	27	BHDS2028	0.5	1	LOD
Iron	ug/l	27	27	1	25	846.00	0	BHDS2028	0.5	1000	RBDD
PAHs											
Naphthalene	ng/l	27	2	10	10	47.00	0	BHDS2077	1	2000	RBDD
Acenaphthylene	ng/l	27	1	10	10	123.00	1	BHDS2070A	1	10	LOD
Acenaphthene	ng/l	27	3	10	10	1680.00	3	BHDS2070A	1	10	LOD
Fluorene	ng/l	27	2	10	10	486.00	2	BHDS2070A	1	10	LOD
Phenanthrene	ng/l	27	4	10	10	194.00	4	BHDS2077	1	10	LOD
Anthracene	ng/l	27	2	10	10	656.00	1	BHDS2070A	1	100	RBDD
Fluoranthene	ng/l	27	4	10	10	1353.00	4	BHDS2070A	1	6.3	RBDD
Pyrene	ng/l	27	3	10	10	759.00	3	BHDS2070A	1	10	LOD
Benzo (a) anthracene	ng/l	27	1	10	10	133.00	1	BHDS2070A	1	10	LOD
Chrysene	ng/l	27	1	10	10	110.00	1	BHDS2070A	1	10	LOD
Benzo (b) fluoranthene	ng/l	27	2	10	10	82.00	2	BHDS2070A	1	0.17	RBDD
Benzo (k) fluoranthene	ng/l	27	0	10	10	10.00	0	N/A	N/A	0.17	RBDD
Benzo (a) pyrene	ng/l	27	2	10	10	101.00	2	BHDS2070A	1	0.17	RBDD



Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Indeno (1,2,3 - cd) pyrene	ng/l	27	3	10	10	33.00	3	BHDS2070A	1	0.17	RBDD
Dibenzo (ah) anthracene	ng/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD
Benzo (ghi) perylene	ng/l	27	3	10	10	46.00	3	TPDS2025	0.3	0.17	RBDD
Total PAHs (USEPA 16)	ng/l	27	2	10	10	5540.00	2	BHDS2070A	1	10	LOD
Aliphatics											
TPH (Aliphatics C5-C6)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aliphatics C6-C8)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aliphatics C8-C10)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aliphatics >C10-C12)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aliphatics >C12-C16)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aliphatics >C16-C21)	µg/l	27	2	10	10	12.00	2	TPDS2077	0.5	10	LOD
TPH (Aliphatics >C21-C35)	µg/l	27	3	10	10	13.00	3	TPDS2077	0.5	10	LOD
TPH (Aliphatics >C35-C40)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD
Aromatics											
TPH (Aromatics C6-C7)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
TPH (Aromatics C7-C8)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aromatics C8-C10)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aromatics >C10-C12)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aromatics >C12-C16)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aromatics >C16-C21)	µg/l	27	1	10	10	26.00	1	BHDS2077	1	10	LOD
TPH (Aromatics >C21-C35)	µg/l	27	3	10	10	30.00	3	BHDS2077	1	10	LOD
TPH (Aromatics >C35-C40)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD

C.2. RPV Screening

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
General Inorganics											
Boron	mg/l	27	6	0.3	0.3	0.40	0	TPDS2072	0.5	1	WAT-PS-10
Total Cyanide	mg/l	27	7	0.01	0.01	0.13	1	BHDS2050	0.2	0.05	WAT-PS-10
Chloride	mg/l	27	10	4	4	50.00	0	TPDS2074	0.5	250	WAT-PS-10

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Ammoniacal Nitrogen	mg/l	27	26	0.1	0.1	2.50	17	BHDS2070A	1	0.5	Water Supply Regs 2001
Sulphate (as SO ₄)	mg/l	27	9	4	4	55.00	0	BHDS2070A	1	250	Water Supply Regs 2001
Sulphide	mg/l	27	0	0.01	0.01	0.01	0	N/A	N/A	0.01	LOD
pH	pH units	27	27	-	4.6	8.10	0	TPDS2074	0.5	9	N/A
Dissolved Organic Carbon	mg/l	27	27	1	2	49.00	27	BHDS2028	0.5	1	LOD
Metals											
Arsenic	ug/l	27	12	0.2	0.2	1.90	0	TPDS2074	0.5	10	WAT-PS-10
Cadmium	ug/l	27	10	0.04	0.04	0.17	0	TPDS2012	0.5	5	WAT-PS-10
Chromium	ug/l	27	27	0.04	0.14	3.60	0	BHDS2070A	1	50	WAT-PS-10
Lead	ug/l	27	27	0.01	0.04	1.94	0	TPDS2014	0.5	10	Water Supply Regs 2001
Mercury	ug/l	27	11	0.08	0.08	0.15	0	BHDS2087	0.5	1	WAT-PS-10
Selenium	ug/l	27	15	0.5	0.5	2.18	0	BH2052	0.5	10	WAT-PS-10
Copper	ug/l	27	27	0.03	2.08	12.24	0	BHDS2028	1	2000	Water Supply Regs 2001

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Nickel	ug/l	27	25	0.3	0.3	2.00	0	BHDS2011	0.5	20	WAT-PS-10
Zinc	ug/l	27	27	0.3	0.78	15.00	0	TPDS2072	0.5	5000	Water Supply Regs 1989
Calcium	ug/l	27	27	1	189	4711.00	27	TPDS2074	0.5	1	LOD
Magnesium	ug/l	27	27	1	88	1000.00	27	BHDS2028	0.5	1	LOD
Iron	ug/l	27	27	1	25	846.00	7	BHDS2028	0.5	200	WAT-PS-10
PAHs											
Naphthalene	ng/l	27	2	10	10	47.00	2	BHDS2077	1	10	LOD
Acenaphthylene	ng/l	27	1	10	10	123.00	1	BHDS2070A	1	10	LOD
Acenaphthene	ng/l	27	3	10	10	1680.00	3	BHDS2070A	1	10	LOD
Fluorene	ng/l	27	2	10	10	486.00	2	BHDS2070A	1	10	LOD
Phenanthrene	ng/l	27	4	10	10	194.00	4	BHDS2077	1	10	LOD
Anthracene	ng/l	27	2	10	10	656.00	2	BHDS2070A	1	10	LOD
Fluoranthene	ng/l	27	4	10	10	1353.00	4	BHDS2070A	1	10	LOD
Pyrene	ng/l	27	3	10	10	759.00	3	BHDS2070A	1	10	LOD
Benzo (a) anthracene	ng/l	27	1	10	10	133.00	1	BHDS2070A	1	10	LOD
Chrysene	ng/l	27	1	10	10	110.00	1	BHDS2070A	1	10	LOD
Benzo (b) fluoranthene	ng/l	27	2	10	10	82.00	0	BHDS2070A	1	100	WAT-PS-10
Benzo (k) fluoranthene	ng/l	27	0	10	10	10.00	0	N/A	N/A	100	WAT-PS-10

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Benzo (a) pyrene	ng/l	27	2	10	10	101.00	2	BHDS2070A	1	10	WAT-PS-10
Indeno (1,2,3 - cd) pyrene	ng/l	27	3	10	10	33.00	0	BHDS2070A	1	100	WAT-PS-10
Dibenzo (ah) anthracene	ng/l	27	0	10	10	10.00	0	N/A	N/A	10	LOD
Benzo (ghi) perylene	ng/l	27	3	10	10	46.00	0	TPDS2025	0.3	100	WAT-PS-10
Total PAHs (USEPA 16)	ng/l	27	2	10	10	5540.00	2	BHDS2070A	1	160	LOD
Aliphatics											
TPH (Aliphatics C5-C6)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aliphatics C6-C8)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aliphatics C8-C10)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aliphatics >C10-C12)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aliphatics >C12-C16)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aliphatics >C16-C21)	µg/l	27	2	10	10	12.00	2	TPDS2077	0.5	10	Water Supply Regs 1989



Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
TPH (Aliphatics >C21-C35)	µg/l	27	3	10	10	13.00	3	TPDS2077	0.5	10	Water Supply Regs 1989
TPH (Aliphatics >C35-C40)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
Aromatics											
TPH (Aromatics C6-C7)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aromatics C7-C8)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aromatics C8-C10)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aromatics >C10-C12)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aromatics >C12-C16)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aromatics >C16-C21)	µg/l	27	1	10	10	26.00	1	BHDS2077	1	10	Water Supply Regs 1989
TPH (Aromatics >C21-C35)	µg/l	27	3	10	10	30.00	3	BHDS2077	1	10	Water Supply Regs 1989
TPH (Aromatics >C35-C40)	µg/l	27	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989

Annex D. Water Environment Risk Assessment – Groundwater

D.1. EQS Screening

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
General Inorganics											
Total cyanide	mg/l	18	18	0.01	0.01	0.04	18	BHDS2053	3.64	0.001	RBDD (as HCN)
Free cyanide	mg/l	18	0	0.05	0.05	0.05	0	N/A	N/A	0.001	RBDD (as HCN)
Complex cyanide	mg/l	18	0	0.05	0.05	0.05	0	N/A	N/A	0.001	RBDD (as HCN)
Thiocyanate	mg/l	18	15	0.2	0.2	0.90	15	BHDS2010	3.24	0.2	LOD
Sulphate (as SO ₄)	mg/l	18	4	4	4	63.00	0	BHDS2057	2.9	400	WAT-SG-53
Sulphide	mg/l	18	1	0.01	0.01	0.02	1	BHDS2059	4.32	0.01	LOD
Chloride	mg/l	18	18	4	8	1034.00	2	BHDS2061	8.5	250	WAT-SG-53
Nitrate	mg/l	18	15	0.5	0.5	74.00	10	BHDS2055	14.35	18	RBDD
Biochemical Oxygen Demand	µg/l	18	2	3	3	19.00	2	BHDS2075	5.59	7	WAT-SG-53 (most conservative)
Chemical Oxygen Demand	µg/l	18	18	5	9	950.00	18	BHDS2075	5.59	5	LOD
Dissolved Organic Carbon	µg/l	18	18	1	1	11.00	18	BHDS2057	2.9	1	LOD



Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Calcium hardness as calcium carbonate	mg/l	18	18	10	20	236.00	18	BHDS2061	8.5	10	LOD
Ammoniacal nitrogen	mg/l	18	18	0.1	1.1	4.20	18	BHDS2045	1.05	0.5	WAT-SG-53 (most conservative - ammonia)
Electrical conductivity	µS/cm	18	18	1	91	899.00	18	BHDS2043	0.74	1	LOD
pH	pH units	18	18	N/A	6.3	9.30	0	BHDS2057	2.9	N/A	
Metals											
Arsenic	µg/l	18	18	0.2	2.5	357.60	2	BHDS2061	8.5	50	RBDD
Cadmium	µg/l	18	17	0.04	0.04	0.32	7	BHDS2043	0.74	0.08	RBDD
Chromium	µg/l	18	18	0.04	0.07	1.96	0	BHDS2057	2.9	4.7	RBDD
Lead	µg/l	18	12	0.01	0.01	0.41	0	BHDS2054	2.56	1.2	RBDD
Mercury	µg/l	18	4	0.08	0.08	0.23	4	BHDS2028	3.14	0.05	RBDD
Selenium	µg/l	18	8	0.5	0.5	2.00	8	BHDS2057	2.9	0.5	LOD
Copper	µg/l	18	18	0.03	0.0706704	0.63	0	BHDS2043	0.74	1	RBDD (bioav)
Nickel	µg/l	18	18	0.3	0.048407	3.39	0	BHDS2061	8.5	4	RBDD (bioav)
Zinc	µg/l	18	18	0.3	0.6251973	19.58	1	BHDS2045	1.05	10.9	RBDD (bioav)
Aluminium	µg/l	18	18	1	2	1099.00	5	BHDS2057	2.9	15	WAT-SG-53
Antimony	µg/l	18	17	0.05	0.05	3.93	16	BHDS2061	8.5	0.05	LOD
Barium	µg/l	18	18	0.08	18	493.00	18	BHDS2061	8.5	0.08	LOD
Beryllium	µg/l	18	10	0.01	0.01	0.08	10	BHDS2028	3.14	0.01	LOD
Calcium	mg/l	18	18	0.1	6	80.50	18	BHDS2061	8.5	1	LOD

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Iron	µg/l	18	7	1	1	1355.00	1	BHDS2075	5.59	1000	RBDD
Manganese	µg/l	18	18	0.02	1.4527386	462.00	3	BHDS2059	4.32	123	RBDD (bioav)
Molybdenum	µg/l	18	15	0.2	0.2	28.00	15	BHDS2059	4.32	0.2	LOD
Boron	mg/l	18	0	0.3	0.3	0.30	0	N/A	N/A	2	WAT-SG-53
Hexavalent Chromium	mg/l	18	1	0.03	0.03	0.04	1	BHDS2028	3.14	0.0034	RBDD
Naphthalene	ng/l	18	0	10	10	10.00	0	N/A	N/A	2000	RBDD
Acenaphthylene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Acenaphthene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Fluorene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Phenanthrene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Anthracene	ng/l	18	0	10	10	10.00	0	N/A	N/A	100	RBDD
Fluoranthene	ng/l	18	0	10	10	10.00	0	N/A	N/A	6.3	RBDD
Pyrene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Benzo (a) anthracene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Chrysene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Benzo (b) fluoranthene	ng/l	18	0	10	10	10.00	0	N/A	N/A	0.17	RBDD
Benzo (k) fluoranthene	ng/l	18	0	10	10	10.00	0	N/A	N/A	0.17	RBDD
Benzo (a) pyrene	ng/l	18	0	10	10	10.00	0	N/A	N/A	0.17	RBDD
Indeno (1,2,3 - cd) pyrene	ng/l	18	0	10	10	10.00	0	N/A	N/A	0.17	RBDD

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Dibenzo (ah) anthracene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Benzo (ghi) perylene	ng/l	18	0	10	10	10.00	0	N/A	N/A	0.17	RBDD
Polynuclear Aromatic Hydrocarbons (total)	ng/l	18	0	160	160	160.00	0	N/A	N/A	10	LOD
TPH (Aliphatics C5-C6)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aliphatics C6-C8)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aliphatics C8-C10)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aliphatics >C10-C12)	µg/l	18	1	10	10	13.00	1	BHDS2043	0.74	10	LOD
TPH (Aliphatics >C12-C16)	µg/l	18	12	10	10	58.00	12	BHDS2043	0.74	10	LOD
TPH (Aliphatics >C16-C21)	µg/l	18	16	10	10	49.00	16	BHDS2043	0.74	10	LOD
TPH (Aliphatics >C21-C35)	µg/l	18	16	10	10	1973.00	16	BHDS2010	3.24	10	LOD
TPH (Aliphatics >C35-C40)	µg/l	18	2	10	10	185.00	2	BHDS2010	3.24	10	LOD
TPH (Aromatics C6-C7)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aromatics C7-C8)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
TPH (Aromatics C8-C10)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aromatics >C10-C12)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH (Aromatics >C12-C16)	µg/l	18	12	10	10	23.00	12	BHDS2043	0.74	10	LOD
TPH (Aromatics >C16-C21)	µg/l	18	11	10	10	21.00	11	BHDS2043	0.74	10	LOD
TPH (Aromatics >C21-C35)	µg/l	18	5	10	10	530.00	5	BHDS2010	3.24	10	LOD
TPH (Aromatics >C35-C40)	µg/l	18	1	10	10	62.00	1	BHDS2010	3.24	10	LOD

D.2. RPV Screening

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
General Inorganics											
Total cyanide	mg/l	18	18	0.01	0.01	0.04	0	BHDS2053	3.64	0.05	WAT-PS-10 (free)
Free cyanide	mg/l	18	0	0.05	0.05	0.05	0	N/A	N/A	0.05	WAT-PS-10
Complex cyanide	mg/l	18	0	0.05	0.05	0.05	0	N/A	N/A	0.05	WAT-PS-10 (free)
Thiocyanate	mg/l	18	15	0.2	0.2	0.90	15	BHDS2010	3.24	0.2	LOD

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Sulphate (as SO ₄)	mg/l	18	4	4	4	63.00	0	BHDS2057	2.9	250	Water Supply Regs 2001
Sulphide	mg/l	18	1	0.01	0.01	0.02	1	BHDS2059	4.32	0.01	LOD
Chloride	mg/l	18	18	4	8	1034.00	2	BHDS2061	8.5	250	WAT-PS-10
Nitrate	mg/l	18	15	0.5	0.5	74.00	4	BHDS2055	14.35	50	WAT-PS-10
Biochemical Oxygen Demand	µg/l	18	2	3	3	19.00	2	BHDS2075	5.59	3	LOD
Chemical Oxygen Demand	µg/l	18	18	5	9	950.00	18	BHDS2075	5.59	5	LOD
Dissolved Organic Carbon	µg/l	18	18	1	1	11.00	18	BHDS2057	2.9	1	LOD
Calcium hardness as calcium carbonate	mg/l	18	18	10	20	236.00	18	BHDS2061	8.5	10	LOD
Ammoniacal nitrogen	mg/l	18	18	0.1	1.1	4.20	18	BHDS2045	1.05	0.5	Water Supply Regs 2001 (ammonium)
Electrical conductivity	µS/cm	18	18	1	91	899.00	18	BHDS2043	0.74	1	LOD
pH	pH units	18	18	N/A	6.3	9.30	0	BHDS2057	2.9	9.5	Water Supply Regs 2001
Metals											
Arsenic	µg/l	18	18	0.2	2.5	357.60	12	BHDS2061	8.5	10	WAT-PS-10
Cadmium	µg/l	18	17	0.04	0.04	0.32	0	BHDS2043	0.74	5	WAT-PS-10
Chromium	µg/l	18	18	0.04	0.07	1.96	0	BHDS2057	2.9	50	WAT-PS-10
Lead	µg/l	18	12	0.01	0.01	0.41	0	BHDS2054	2.56	10	Water Supply Regs 2001

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Mercury	µg/l	18	4	0.08	0.08	0.23	0	BHDS2028	3.14	1	WAT-PS-10
Selenium	µg/l	18	8	0.5	0.5	2.00	0	BHDS2057	2.9	10	WAT-PS-10
Copper	µg/l	18	18	0.03	1.03	3.49	0	BHDS2057	2.9	2000	Scottish DWS
Nickel	µg/l	18	6	0.3	0.3	12.60	0	BHDS2061	8.5	20	WAT-PS-10
Zinc	µg/l	18	18	0.3	2.7	29.40	0	BHDS2045	1.05	5000	1989 UK DWS
Aluminium	µg/l	18	18	1	2	1099.00	1	BHDS2057	2.9	200	Water Supply Regs 2001
Antimony	µg/l	18	17	0.05	0.05	3.93	0	BHDS2061	8.5	5	WAT-PS-10
Barium	µg/l	18	18	0.08	18	493.00	18	BHDS2061	8.5	0.7	WAT-PS-10
Beryllium	µg/l	18	10	0.01	0.01	0.08	0	BHDS2028	3.14	4	WAT-PS-10
Calcium	mg/l	18	18	0.1	6	80.50	0	BHDS2061	8.5	250	Water Supply Regs 1989
Iron	µg/l	18	7	1	1	1355.00	2	BHDS2075	5.59	200	Water Supply Regs 2001
Manganese	µg/l	18	18	0.02	3	880.00	11	BHDS2021A	5.38	50	WAT-PS-10
Molybdenum	µg/l	18	15	0.2	0.2	28.00	15	BHDS2059	4.32	0.2	LOD
Boron	mg/l	18	0	0.3	0.3	0.30	0	N/A	N/A	1	WAT-PS-10
Hexavalent Chromium	mg/l	18	1	0.03	0.03	0.04	1	BHDS2028	3.14	0.03	LOD
Naphthalene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Acenaphthylene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Acenaphthene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Fluorene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Phenanthrene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Anthracene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Fluoranthene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Pyrene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Benzo (a) anthracene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Chrysene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Benzo (b) fluoranthene	ng/l	18	0	10	10	10.00	0	N/A	N/A	100	WAT-PS-10
Benzo (k) fluoranthene	ng/l	18	0	10	10	10.00	0	N/A	N/A	100	WAT-PS-10
Benzo (a) pyrene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	WAT-PS-10
Indeno (1,2,3 - cd) pyrene	ng/l	18	0	10	10	10.00	0	N/A	N/A	100	WAT-PS-10
Dibenzo (ah) anthracene	ng/l	18	0	10	10	10.00	0	N/A	N/A	10	LOD
Benzo (ghi) perylene	ng/l	18	0	10	10	10.00	0	N/A	N/A	100	WAT-PS-10
Polynuclear Aromatic Hydrocarbons (total)	ng/l	18	0	160	160	160.00	0	N/A	N/A	160	LOD
TPH (Aliphatics C5-C6)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aliphatics C6-C8)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aliphatics C8-C10)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
TPH (Aliphatics >C10-C12)	µg/l	18	1	10	10	13.00	1	BHDS2043	0.74	10	Water Supply Regs 1989
TPH (Aliphatics >C12-C16)	µg/l	18	12	10	10	58.00	12	BHDS2043	0.74	10	Water Supply Regs 1989
TPH (Aliphatics >C16-C21)	µg/l	18	16	10	10	49.00	16	BHDS2043	0.74	10	Water Supply Regs 1989
TPH (Aliphatics >C21-C35)	µg/l	18	16	10	10	1973.00	16	BHDS2010	3.24	10	Water Supply Regs 1989
TPH (Aliphatics >C35-C40)	µg/l	18	2	10	10	185.00	2	BHDS2010	3.24	10	Water Supply Regs 1989
TPH (Aromatics C6-C7)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aromatics C7-C8)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aromatics C8-C10)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aromatics >C10-C12)	µg/l	18	0	10	10	10.00	0	N/A	N/A	10	Water Supply Regs 1989
TPH (Aromatics >C12-C16)	µg/l	18	12	10	10	23.00	12	BHDS2043	0.74	10	Water Supply Regs 1989
TPH (Aromatics >C16-C21)	µg/l	18	11	10	10	21.00	11	BHDS2043	0.74	10	Water Supply Regs 1989
TPH (Aromatics >C21-C35)	µg/l	18	5	10	10	530.00	5	BHDS2010	3.24	10	Water Supply Regs 1989
TPH (Aromatics >C35-C40)	µg/l	18	1	10	10	62.00	1	BHDS2010	3.24	10	Water Supply Regs 1989

Annex E. Water Environment Risk Assessment – Surface Water

E.1. EQS Screening

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
General Inorganics											
pH (field)	pH units	12	12	N/A	4.6	7.53	0	ALLT NA FHERNA EAST	0	9	n/a
pH	pH units	12	12	N/A	6.2	7.30	0	ALLT RUIGHE MAGAIG EAST	0	10	n/a
Temperature (field)	degrees C	12	12	N/A	8.77	11.39	0	ALLT RUIGHE MAGAIG EAST	0	15	n/a
conductivity (field)	ms/cm	12	12	N/A	17.53	125.10	0	FEITH MOR EAST	0	1000	n/a
dissolved oxygen (field)	%	12	12	1	90.6	105.40	12	DULNAIN EAST	0	1	LOD
biochemical oxygen demand	ug/l	12	0	3	3	3.00	0	N/A	N/A	3	LOD
chemical oxygen demand	ug/l	12	12	5	13	25.00	12	DULNAIN EAST	0	5	LOD
dissolved organic carbon	mg/l	12	12	1	3	7.00	12	LOCH ALVIE	0	1	LOD
sulphate (as SO4)	mg/l	12	0	4	4	4.00	0	N/A	N/A	400	WAT-SG-53
sulphide	mg/l	12	0	0.001	0.001	0.00	0	N/A	N/A	0.000025	WAT-SG-53 (HS)
chloride	mg/l	12	11	4	4	40.00	0	FEITH MOR EAST	0	250	EQS

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Total cyanide	mg/l	12	3	0.01	0.01	0.02	3	SPEY CENTRAL	0	0.001	EQS(HCN)
Free cyanide	mg/l	12	0	0.05	0.05	0.05	0	N/A	N/A	0.001	EQS(HCN)
nitrate	mg/l	12	1	0.5	0.5	3.60	1	DULNAIN EAST	0	0.5	LOD
Ammoniacal nitrogen	mg/l	12	1	0.1	0.1	0.10	1	LOCH ALVIE	0	0.1	LOD
Antimony	ug/l	12	5	0.05	0.05	0.06	5	LOCH ALVIE	0	0.05	LOD
Beryllium	ug/l	12	9	0.01	0.01	0.09	9	ALLT NA FHERNA EAST	0	0.01	LOD
Arsenic	ug/l	12	5	0.2	0.2	0.30	0	DULNAIN WEST	0	50	RBDD
Cadmium	ug/l	12	2	0.04	0.04	0.05	0	DULNAIN WEST	0	0.08	RBDD
Chromium	ug/l	12	11	0.04	0.04	0.91	0	DULNAIN EAST	0	4.7	RBDD
Lead	ug/l	12	12	0.01	0.1	0.32	0	DULNAIN EAST	0	1.2	RBDD
Mercury	ug/l	12	5	0.08	0.08	0.17	5	DULNAIN WEST	0	0.05	RBDD
Selenium	ug/l	12	0	0.5	0.5	0.50	0	N/A	N/A	0.5	LOD
Copper	ug/l	12	12	0.03	0.2869269	2.27	3	ALLT NA FHERNA EAST	0	1	RBDD (bioav)
Nickel	ug/l	12	12	0.3	0.0363183	0.13	0	ALLT RUIGHE MAGAIG EAST	0	4	RBDD (bioav)

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Zinc	ug/l	12	12	0.3	0.7056583	1.45	0	FEITH MOR WEST	0	10.9	RBDD (2014) (bioav)
Aluminium	ug/l	12	12	1	11	26.00	10	LOCH ALVIE	0	15	RBDD
Iron	ug/l	12	10	1	1	99.00	0	FEITH MOR EAST	0	1000	RBDD
Manganese	ug/l	12	12	0.02	0.0194571	1.88	0	FEITH MOR EAST	0	123	RBDD(2014) (bioav)
Molybdenum	ug/l	12	5	0.2	0.2	0.70	5	SPEY CENTRAL	0	0.2	LOD
Barium	ug/l	12	12	0.08	6.82	27.19	12	FEITH MOR EAST	0	0.08	LOD
Calcium	ug/l	12	12	1	443	3196.00	12	ALLT RUIGHE MAGAIG WEST	0	1	LOD
Boron	mg/l	12	0	0.3	0.3	0.30	0	N/A	N/A	2	EQS
Hexavalent Chromium	mg/l	12	0	0.03	0.03	0.03	0	N/A	N/A	0.0034	RBDD
Naphthalene	ng/l	12	0	10	10	10.00	0	N/A	N/A	2000	RBDD
Acenaphthylene	ng/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
Acenaphthene	ng/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
Fluorene	ng/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
Phenanthrene	ng/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
Anthracene	ng/l	12	0	10	10	10.00	0	N/A	N/A	100	RBDD
Fluoranthene	ng/l	12	0	10	10	10.00	0	N/A	N/A	6.3	RBDD
Pyrene	ng/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD



Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Benzo(a)anthracene	ng/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
Chrysene	ng/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
Benzo(b)fluoranthene	ng/l	12	0	10	10	10.00	0	N/A	N/A	0.17	RBDD
Benzo(k)fluoranthene	ng/l	12	0	10	10	10.00	0	N/A	N/A	0.17	RBDD
Benzo(a)pyrene	ng/l	12	0	10	10	10.00	0	N/A	N/A	0.17	RBDD
Indeno(1,2,3-cd)pyrene	ng/l	12	0	10	10	10.00	0	N/A	N/A	0.17	RBDD
Dibenz(a,h)anthracene	ng/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
Benzo(ghi)perylene	ng/l	12	0	10	10	10.00	0	N/A	N/A	0.17	RBDD
TPH7 - Aliphatic >C5 - C6	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH7 - Aliphatic >C6 - C8	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH7 - Aliphatic >C8 - C10	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH7 - Aliphatic >C10 - C12	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH7 - Aliphatic >C12 - C16	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH7 - Aliphatic >C16 - C21	ug/l	12	1	10	10	54.00	1	ALLT NA FHERNA EAST	0	10	LOD
TPH7 - Aliphatic >C21 - C35	ug/l	12	3	10	10	205.00	3	ALLT NA FHERNA EAST	0	10	LOD

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
TPH7 - Aliphatic (C5 - C35)	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH7 - Aromatic >C5 - C7	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH7 - Aromatic >C7 - C8	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH7 - Aromatic >C8 - C10	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH7 - Aromatic >C10 - C12	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH7 - Aromatic >C12 - C16	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH7 - Aromatic >C16 - C21	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD
TPH7 - Aromatic >C21 - C35	ug/l	12	1	10	10	13.00	1	ALLT NA FHERNA EAST	0	10	LOD
TPH7 - Aromatic (C5 - C35)	ug/l	12	0	10	10	10.00	0	N/A	N/A	10	LOD

Annex F. Phytotoxicity Risk Assessment

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
General Inorganics											
pH		109	109	n/a	4	9.20	1	BHDS2040	2	9	MAFF CoP (acid pH)
pH		109	109	n/a	4	9.20	77	BHDS2040	2	5.5	MAFF CoP (alkaline pH)
Metals											
Arsenic	mg/kg	110	109	1	1	16.00	0	TPDS2039	4	50	pH>5 MAFF CoP
Cadmium	mg/kg	110	2	1	1	2.00	0	TPDS2039	3.3	3	pH>5 MAFF CoP
Chromium	mg/kg	110	110	1	3	130.00	0	BHDS2040	2	400	pH>5 MAFF CoP
Lead	mg/kg	110	110	1	4	49.00	0	TPDS2060	2.15	300	pH>5 MAFF CoP
Mercury	mg/kg	110	0	1	1	1.00	0	N/A	N/A	1	pH>5 MAFF CoP
Selenium	mg/kg	110	0	1	1	1.00	0	N/A	N/A	3	pH>5 MAFF CoP
Copper	mg/kg	110	110	1	1	65.00	0	BHDS2072	0.3	80	pH5-5.5 MAFF
Copper	mg/kg	110	110	1	1	65.00	0	BHDS2072	0.3	100	pH5.5-6 MAFF

Determinand	Units	No. of Samples	No. > MRL	MRL	Min	Max	No. > Assessment Criteria	Location of Maximum Concentration	Location of Depth (m bgl)	Assessment Criteria	Source
Copper	mg/kg	110	110	1	1	65.00	0	BHDS2072	0.3	135	pH6-7 MAFF
Copper	mg/kg	110	110	1	1	65.00	0	BHDS2072	0.3	200	pH>7 MAFF
Nickel	mg/kg	110	109	1	1	51.00	1	BHDS2040	2	50	pH5-5.5 MAFF
Nickel	mg/kg	110	109	1	1	51.00	0	BHDS2040	2	60	pH5.5-6 MAFF
Nickel	mg/kg	110	109	1	1	51.00	0	BHDS2040	2	75	pH6-7 MAFF
Nickel	mg/kg	110	109	1	1	51.00	0	BHDS2040	2	110	pH>7 MAFF
Zinc	mg/kg	110	110	1	4	190.00	0	TPDS2060	2.15	200	pH5-7 MAFF
Zinc	mg/kg	110	110	1	4	190.00	0	TPDS2060	2.15	300	>pH7 MAFF