ENGIE Buildings Limited

GROUND INVESTIGATION REPORT

Project RED: Manchester Royal Infirmary

70048625-11173(1)
OCTOBER 2018

CONFIDENTIAL

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1 INTRODUCTION

1.1 AUTHORISATION AND OBJECTIVES

WSP was commissioned by ENGIE Buildings Limited, to undertake a Ground Investigation at part of Manchester Royal Infirmary, Oxford Road, Manchester, M13 9WL, henceforth referred to as the site. A site location plan is included as Figure 1 in Appendix A.

The objectives of this assessment are to identify any development constraints associated with ground conditions and contamination and make initial recommendations in relation to geotechnical parameters to inform the design of proposed ground works and structures.

1.2 DEVELOPMENT PROPOSALS

The approximately 0.52ha site currently comprises ambulance bays and two single storey modular buildings (occupied by the RESUS (emergency) and the walk-in emergency centre departments) adjacent to the bays.

The proposed development is centred around the existing ambulance bay and comprises the construction of a two storey RESUS department and a single storey Majors and Minors building.

Externally, parking areas will be provided for ambulances and police vehicles and a new entrance canopy will provide on the northern elevation of the existing Hospital building.

A current site layout and features plan is presented as Figure 2 in Appendix A and an initial proposed floor plan layout (drawing no. ADP-00-00-DR-A-1025) is also included in Appendix A.

1.3 PREVIOUS REPORTS

WSP has previously produced the following report for the site:

- WSP (2018) *Project RED: Contaminated Land Preliminary Risk Assessment (Phase 1 Assessment).* Ref: 70037279-11067(1), dated: 1 June 2018.

In addition, reference has also been made to the following documents produced by Sub Surface North West Limited (Sub Surface);

- Hand dug trial pits undertaken in June 2018 (included with WSP logs within Appendix C) and provided by email; and,
- Technical Report, Ground Investigation at A&E Manchester Royal Infirmary; Report Ref. 5971, dated January 2015.

1.4 LIMITATIONS AND RELIANCE

This investigation has been undertaken with due consideration to the guidance in '*Model Procedures for the Management of Land Contamination',* Contaminated Land Report 11 (CLR 11), (Environment Agency, 2004), and in general accordance with the British Standard 'Investigation of potentially contaminated sites – Code of Practice' BS EN 10175:2011, in the context of the investigation.

The report is addressed to and may be relied upon by the following parties:

ENGIE Buildings Limited
The Lighthouse
14 The Quays
Salford
Manchester
M50 3BF

This assessment has been prepared for the sole use of the above-named party. This report shall not be relied upon or transferred to any other parties without the express written authorisation of WSP. No responsibility will be accepted where this report is used either in its entirety or in part, by any other party.

A copy of the WSP General Limitations is included in Appendix B.

2 THE SITE AND EXISTING INFORMATION

2.1 SITE DETAILS

A summary of pertinent site information is provided in Table 1.

Table 1: Summary of Site Details

Site Address	Proposed redevelopment site at the current A&E (RESUS and walk-in) departments at Manchester Royal Infirmary (MRI), Oxford Road, M13 9WL
National Grid Reference and Topography:	385110, 396290 at approximately 44 metres above ordnance datum (m AOD)
Approximate Surface Area and Elevation:	Approximately 0.52 hectares
Current Site Use:	The rectangular shaped site is orientated northwest-southeast in the northeast of the wider MRI footprint, near the corner of Upper Brook Street and Grafton Street. The site is currently predominantly used as follows: Ambulance parking bays in the north; A single storey modular building in the southeast; The accident and emergency departments in the northwest with a waste area adjacent to the southeast.
Surrounding Land Use:	The following land uses are adjacent to the site: Northwest: The MRI clinical research facility and three commercial premises (with frontage onto Grafton Street). Northeast: A car parking area for the emergency departments is immediately adjacent to the site with Upper Brook Street and the Manchester Blood Donor centre further beyond. Southwest: MRI Buildings. Southeast: MRI Buildings.

2.2 SITE SETTING

A summary of the site setting is provided in Table 2.

Table 2: Site Setting

Geology	British Geological Survey (BGS) mapping indicates the site is underlain by superficial deposits comprising Glacial Till (Diamicton). The solid geology is understood to comprise the Chester Formation in the northwest corner, underlain by the Manchester Marls Formation, which sub-crops beneath the majority of the site. It is understood that the superficial deposits extend to approximately 13 metres below ground level (m bgl) and that sand and gravel bands are frequently recorded within the Glacial Till.
Hydrogeology	The Environment Agency (EA) classifies the superficial deposits (Glacial Till) as a Secondary Undifferentiated Aquifer, and the underlying Chester Formation as a Principal Aquifer and Manchester Marls Formation as a Secondary B Aquifer. The site is understood to be within a source protection zone III (SPZ III), this is the total area needed to support the discharge from the protected groundwater source. The nearest recorded groundwater abstraction is 768m northeast for industrial/commercial use in a heat pump.

Hydrology	The nearest surface water feature is understood to be an unnamed culverted river (potentially Corn Brook based on historical mapping) located approximately 440m northwest, followed by the River Medlock which is located approximately 1km northwest.
Site History	**On Site** Earliest mapping (dated 1848) reviewed as part of the WSP Phase 1 PRA 2018 reported residential properties and Nelson Street at the north-western end of the site and the remainder of the site as undeveloped. By the early 1890s Lothair Street and residential areas had been developed on the south-eastern portion of the site. The site remained unchanged until 1950 mapping, which showed several of the residential properties had been cleared (additional clarification on potential world war II bombing discounted that as a reason for the clearing). The 1976 mapping shows the road layout but all residential properties have been cleared. The 1992 mapping shows the site as part of the MRI with the current buildings and layout. **Off Site** The earliest mapping showed the site was located in a largely residential setting from 1848 to 1976; by the 1978 mapping the residential properties that surrounded the site on all sides have been cleared prior to the development of the wider area into the MRI and the university campus to the north. The Royal Eye Hospital is shown approximately 100m west from 1891 onwards (it is still present today) and by the 1908 the Christie Hospital is shown approximately 100m south; the Christie Hospital expands and is labelled as Manchester Royal Infirmary by the 1933 mapping. An electricity substation is shown approximately 20m southeast of the site from 1984 onwards.
Invasive Species	Suspected Japanese Knotweed was noted offsite to the northeast on the hospital boundary with Upper Brook Street.

2.3 PRELIMINARY CONCEPTUAL SITE MODEL

The risks from contaminated land are assessed with consideration of the relationship between potentially hazardous contaminant sources (e.g. chemicals, ground gas) and vulnerable receptors (e.g. groundwater, people). If there is a viable pathway between the potentially hazardous source and the receptor, there is a potential risk.

The guiding principle behind this approach is an attempt to establish connecting links between a hazardous source, via an exposure pathway to a potential receptor, referred to as a 'pollutant linkage'. If there is no pollutant linkage, then there is no risk.

Therefore, only where a viable pollutant linkage is established does this assessment go onto consider the level of risk. This approach is in accordance with the Environment Agency Model Procedures (CLR11).

2.3.1 PRELIMINARY GROUND MODEL

The ground conditions are anticipated to comprise Made Ground beneath the hospital building and the associated ambulance bays underlain by a significant thickness of Glacial Till (clay) (secondary undifferentiated aquifer) and underlying bedrock Chester Pebble Beds Formation (principal aquifer) and the Manchester Marls Formation (secondary B aquifer).

There is a potentially significant thickness of Till likely comprising mostly lower permeability soils, which will serve to limit migration of any mobile contamination into the underlying Principal and Secondary B Aquifers and wider hydro-geological system, which is considered to be of low to moderate sensitivity.

The proposed development will comprise buildings and hardstanding; there will be no soft landscaped areas.

2.3.2 SOURCES, PATHWAYS AND RECEPTORS

The potential sources, pathways and receptors relevant to the proposed development have been identified and are presented below. The assessment assumes that no remedial measures are implemented to mitigate risks during or within the redevelopment.

POTENTIAL CONTAMINANT SOURCES

Given the historical use of part of the site for residential purposes and the current use as a hospital the potential sources are considered to include those listed below:

- Contaminants within soil and groundwater associated with the sites current use as a hospital – e.g. diesel from fuel tanks associated with the generators 20m offsite to the southeast, chemicals via broken drains.
- Chemical contaminants or asbestos associated with Made Ground that may have been used historically to infill basements of the demolished residential properties or to raise or level the site.
- Generation of hazardous ground gases from areas of deep Made Ground, if present.

Potential off-site source of contamination or hazardous ground gases, additional to those listed above, that could potentially affect the site have not been identified.

POTENTIAL RECEPTORS

Given the absence of soft landscaping within the new development, the exposure pathways relevant to future users and maintenance workers are considered limited. The relevant potential receptors are considered to include:

- Construction workers during redevelopment.
- Neighbouring site users during redevelopment.
- Future site users (patients and hospital workers) and maintenance workers (only if volatile chemicals are present)
- Groundwater in the Secondary Undifferentiated (superficial) and Principal and Secondary B Aquifers (bedrock).
- Down-gradient surface waters.
- Infrastructure (e.g. potable water pipes, foundations).

POTENTIAL MIGRATION PATHWAYS

Relevant potential pathways are considered to include:

- Direct contact, ingestion or inhalation of soil bound contaminants / dust (during ground works only).
- Inhalation of accumulated vapours associated with soil / groundwater contamination or hazardous ground gases.
- Migration of leachable / mobile contamination.

- Direct contact between contaminant and below ground infrastructure.

2.3.3 POLLUTANT LINKAGE ASSESSMENT

In summary, the following pollutant linkages are considered to be potentially viable and to require confirmation via intrusive investigation:

DURING REDEVELOPMENT

1. Human health risks to ground workers and third parties (neighbours) associated with possible inhalation of asbestos fibres released during Made Ground excavation.
2. Human health risks to ground workers associated with direct contact/ ingestion/ inhalation of chemical contamination and/ or ground gases.

The above potential linkages can be broken by the use of appropriate health and safety precautions and working practices during redevelopment, thereby removing potentially complete linkages.

AFTER REDEVELOPMENT

The following potentially complete linkages are possible:

3. Potential risks to future site users and maintenance workers from inhalation of volatile contamination or hazardous ground gases, if present.
4. Potential risks to future site users if new potable water pipes are laid in contaminated soils.
5. Migration of mobile contamination to wider groundwater body and surface waters. This is considered unlikely but not possible to rule out at this stage.
6. Potential risks to foundations from direct contact with aggressive ground conditions.

The above potentially complete pollutant linkages could be broken by completing some relatively basic remediation / mitigation, e.g. removal of any identified hot spots of contamination, appropriate re-use of materials, provision of barrier pipe for potable water supplies in affected area and provision of gas mitigation measures (if required).

The presence or otherwise of the above potentially complete pollutant linkages will need to be assessed via intrusive ground investigation.

3 GROUND INVESTIGATION WORKS

3.1 FIELDWORKS

The site investigation was completed in general accordance with BS5930:2015 'Code of Practice for Site Investigation' and BS10175:2011 'Investigation of Potentially Contaminated Sites – Codes of Practice'.

All fieldworks were completed under the full-time supervision of a WSP engineer. A summary of the scope of works is provided in Table 3. The borehole / monitoring well locations are presented on Figure 3 and borehole logs are included in Appendix C.

Table 3: Summary of Fieldworks

Activity	Dates	Details
Utility Tracing and Service Clearance	13 August 2018	To inform on potential ground/service constraints and provide an updated record in advance of the intrusive investigation.
Concrete Coring, Hand Pitting and Rotary Drilling	20 – 31 August 2018	After concrete coring, boreholes were initiated using hand pitting to 1.5m bgl. Boreholes were then advanced using a combination of dynamic sampling and a rotary coring sampling technique (BH1 and BH2). Due to lack of access at BH3, this borehole was advanced using a hand-held dynamic sampling technique. Whilst logging soils, the WSP engineer recorded visual and olfactory evidence of contamination and screened selected samples for volatile organic compounds (VOCs) in headspace above the soil using a Photo Ionisation Detector (PID). The results are provided on the borehole logs. All locations were installed with 50mm diameter ground gas/groundwater monitoring wells and finished at the surface with a flush, traffic rated cover. Installation details are provided on the borehole logs.
Well Development	31 August 2018	The newly installed monitoring wells were 'developed' to remove sediment and drilling fluids.
Groundwater Monitoring and Sampling	6 and 25 August 2018	Representative groundwater samples were collected from BH1 and BH2 (BH3 was dry) using a bailed method on two occasions. The second groundwater sampling round was undertaken due to the high sediment content of samples collected in round 1. The second set of samples are considered to be more representative of groundwater.
Ground gas monitoring	6 and 28 September and 5 and 10 October 2018	Ground gas flow rates and concentrations recorded in all three wells on four occasions.

The borehole locations, drilled depths and installation details are summarised in Table 4. The positioning of boreholes was limited by the nature of the site, which needed to continue operating as a busy ambulance bay for the duration of the works. Liaison with ENGIE was undertaken prior to the drilling works and each location was approved prior to drilling.

Table 4: Borehole and Monitoring Well details

BH Ref.	Location and Rationale	Drilled Depth (m)	Screened Interval (m bgl)	Screened Strata	Well Diameter (mm)
BH1	Located at the northern end of the current ambulance bays within the footprint of Nelson Street (based on historical maps) and beneath the new building structure.	15.80	1.0 – 4.0	Made Ground and Glacial Till	50
BH2	Located at the southern end of the current ambulance bays within the footprint of former houses (based on historical maps) and beneath the new building structure.	12.65	1.0 – 4.0	Glacial Till	50
BH3	Located beneath the position of the former houses and the new building structure at the southern end of the site adjacent to the current modular building used for the emergency walk-in clinic.	2.50	0.5 – 2.5	Made Ground and Glacial Till	50

3.2 LABORATORY ANALYSIS AND TESTING

3.2.1 CONTAMINATION TESTING

Selected soil samples were submitted for analysis at ALS laboratories which uses United Kingdom Accreditation Service (UKAS) and Environment Agency Monitoring Certification Scheme (MCERTS) accredited methods, where applicable.

Four soil samples were analysed for potential contaminants of concern, including:

- Metals suite
- pH
- Total Petroleum Hydrocarbons Criteria Working Group (TPH CWG)
- Polyaromatic Hydrocarbons (PAH)
- Asbestos soil screen.

Four groundwater samples (two samples from each of BH1 and BH2, collected on two separate visits were analysed for the following:

- Metals suite
- TPH CWG
- PAH

3.2.2 GEOTECHNICAL TESTING

Geotechnical testing scheduled by WSP comprised the following:

- Atterberg Limits
- Moisture Content
- Undrained Unconsolidated Triaxial
- Point Load Index
- pH
- Water soluble sulphate (2:1)
- Dissolved sulphate (in groundwater)

The results of the chemical and geotechnical testing are presented in Appendix D.

3.3 GROUND GAS AND GROUNDWATER MONITORING

Ground gas monitoring was undertaken in accordance with the Construction Industry Research and Information Associated (CIRIA) guidance document 'Assessing Risk posed by Hazardous Ground Gases to Buildings (CIRIA C665, dated 2007)' (we have interpreted the guidance for this site as requiring 4 visits over 1 month), 'BS 8576 Guidance on Investigation for Ground Gas', and BS 8485:2015 Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for New Buildings.

The following parameters were recorded in each borehole:

- Ground gas flow rates (l/hr)
- Barometric pressure
- Concentrations of methane, carbon dioxide, and oxygen
- Depth to groundwater
- Depths / thicknesses of Light Non-Aqueous Phase Liquid (LNAPL) / Dense Non-Aqueous Phase Liquid (DNAPL) (if present)

A copy of the ground gas monitoring results is presented in Appendix E and a risk assessment is included in Section 5.

4 GROUND INVESTIGATION RESULTS

4.1 GROUND CONDITIONS

A summary of ground conditions recorded during the WSP investigation is provided in Table 5. The borehole logs are presented in Appendix C. Further detail on the materials are provided below and in Section 7.

Table 5: Summary of Strata Encountered

Stratum Name	Depth to Base (m bgl)	Thickness (m)
Hardstanding	0.05 – 0.34	0.05 – 0.34
Made Ground	0.60 – 2.10	0.26 – 1.84
Glacial Till	>2.50 – 12.00 (where proven)	>0.50 – 11.35 (where proven)
Manchester Marls Formation	>15.80	>3.80

4.1.1 MADE GROUND

Made Ground was recorded beneath hardstanding in all three locations to depths of between 0.60m bgl and 2.10m bgl and comprised light brown or grey sandy gravel of limestone (subbase). BH3 encountered cohesive Made Ground underlying this granular layer, comprising light brown sandy gravelly clay with gravel sized fragments of brick, concrete and glass from 0.30m bgl to 2.0m bgl.

4.1.2 GLACIAL TILL

Superficial strata comprising Glacial Till was encountered in all locations beneath Made Ground to depths of between 11.95m bgl (BH2) and 12.0m bgl (BH1) (the maximum depth was not recorded in BH3 (>2.50m bgl)).

Glacial Till deposits comprised gravelly silty clay where gravels were rounded to subangular, fine to coarse and of various lithologies. Glacial Till generally became stiffer and contained less gravel with depth.

Gravel layers were recorded in both of the deeper boreholes at depths of 11.75m bgl to 12.00m bgl (BH1) and 10.40m bgl to 11.20m bgl (BH2).

4.1.3 MANCHESTER MARLS FORMATION

Bedrock comprising the Manchester Marls Formation was encountered in BH1 and BH2 at 12.0m bgl and 11.95m bgl, respectively. Bedrock comprised reddish brown slightly micaceous clayey Mudstone with occasional thin bands of less clayey stronger mudstone, greenish grey mottled reddish-brown Breccia and greenish grey mudstone.

The maximum extent of the bedrock was not established however BGS mapping indicates the approximate thickness if 45m in the Manchester area.

4.1.4 EVIDENCE OF CONTAMINATION

Evidence of visual or olfactory evidence of contamination was not observed during the drilling and no elevated PID readings (>10ppm) were recorded.

4.2 GROUNDWATER CONDITIONS

Groundwater strikes were not recorded during drilling. Groundwater resting levels within the monitoring wells from the four monitoring visits are summarised in Table 6.

Table 6: Summary of Groundwater Data

Borehole ID	Screened Section (m bgl)	Depth to Product (m bgl)	Depth to Water (m bgl)				Depth to Base (m bgl)	Strata water resting within
			06-Sept	28-Sept	05-Oct	10-Sept		
BH1	1.0 – 4.0	NA	2.27	2.31	2.32	2.35	3.93	Glacial Till
BH2	1.0 – 4.0	NA	1.55	1.64	1.98	2.05	3.99	Glacial Till
BH3	0.5 – 2.5	NA	DRY	DRY	DRY	2.18	2.40	Glacial Till

It is considered likely given the granular nature of the Made Ground (predominantly subbase) and the higher gravel content of the shallower Glacial Till deposits that the encountered water is perched water within Made Ground and the granular layers within the Glacial Till.

Given the low permeability nature of clay (Glacial Till) and the thickness (>10m) of the Glacial Till deposits shallow groundwater is not considered to be in hydraulic connectivity with the underlying bedrock.

4.3 ENVIRONMENTAL LABORATORY RESULTS

4.3.1 SOIL

Four selected soil samples (two Made Ground and two Glacial Till) were analysed for chemical contamination. A review of laboratory data noted the following:

- Petroleum hydrocarbon concentrations were generally trace or below the laboratory limit of detection (<LOD). The detected compounds were generally the lower toxicity hydrocarbon ranges.
- BTEX or MTBE were not detected above the laboratory LOD in any of the four samples.
- PAH compounds were <LOD in the two natural soil samples and at low/trace concentrations in the two Made Ground samples.
- Metals were detected at broadly consistent concentrations across all four samples analysed and are considered likely to reflect background concentrations.
- Asbestos fibres were not detected in the two Made Ground samples.

The risks associated with soil chemical concentrations are assessed in Section 5.

4.3.2 GROUNDWATER

Two rounds of groundwater sampling were completed on BH1 and BH2 (BH3 was dry). A review of laboratory data noted the following:

- Concentrations of metals and PAH compounds were generally consistent between samples during round 1. The lower concentrations encountered in samples from round 2 are considered to be representative of background concentrations.
- Petroleum hydrocarbon concentrations were elevated in BH2 during sampling round 1. As a result, both wells were resampled. Samples from round 2 contained only trace concentrations of petroleum hydrocarbons, considered to be consistent with background concentrations.
- BTEX or MTBE were not detected in groundwater from BH1 or BH2 during either sampling round.

The risks associated with groundwater chemical concentrations are assessed in Section 5.

5 GENERIC QUANTITATIVE RISK ASSESSMENT

5.1 INTRODUCTION

In the United Kingdom, the presence of contamination within soil or groundwater at a site is generally only of concern if there is a potentially unacceptable risk to a sensitive receptor.

The risk assessment process begins with screening chemical concentrations in soil or groundwater against generic conservative screening values (a process called Generic Quantitative Risk Assessment - GQRA). GQRAs are performed to assess risks to human health and controlled waters.

Potential risks to human health from asbestos in soil is discussed in Section 5.3 and risks from ground gases are assessed in Section 5.6.

5.2 HUMAN HEALTH RISK ASSESSMENT

5.2.1 HUMAN HEALTH SCREENING CRITERIA

The human health Generic Assessment Criteria (GAC) screening values used to assess the risks from soil chemical concentrations have been developed by WSP using CLEA Workbook v1.071 modelling tool. The same methodology has also been used to produce the WSP screening values for the risk to human health posed by volatile compounds in groundwater.

Further details on the values used in this assessment are provided in Appendix F. A potential risk exists if the soil concentration exceeds the GAC for that chemical.

Based on the proposed use of the site as a hospital (commercial usage), the soil and groundwater chemical data has been compared against a commercial end use GAC. However, given the entire site will be covered by buildings or hardstanding, the exposure pathways would be limited to inhalation of volatile compounds, therefore the use of commercial GAC is considered to be a conservative approach.

A conservative soil organic matter (SOM) content of 1% has been assumed for screening purposes.

5.2.2 SOIL ASSESSMENT RESULTS

The output from the soil screening assessment is presented in Appendix G.

None of the soil samples analysed exceeded the human health GAC. This is consistent with the absence of visual or olfactory evidence of contamination and no elevated PID readings (>10ppm) recorded during the site investigation.

This confirms that soils are suitable to remain at the surface within a commercial setting and are not likely to pose a potential risk to construction workers.

5.2.3 GROUNDWATER ASSESSMENT RESULTS

VOCs in shallow groundwater may represent a potential risk via migration and indoor/outdoor inhalation.

Volatile compounds within the standard suite of compounds analysed (BTEX and naphthalene) have not been detected above LOD in groundwater and the groundwater vapour GAC for these

compounds are not exceeded. Therefore, the potential risk to human health from vapour inhalation from a groundwater source is considered to be negligible.

5.3 ASBESTOS IN SOIL

Four samples of Made Ground were screened for the presence of asbestos fibres. Asbestos fibres were not identified within any of the four samples.

Although asbestos was not detected in any of the four samples analysed, given the generic nature of Made Ground it is considered there is potential for asbestos fibres to be present in Made Ground. Therefore, precautions to limit the generation of airborne fibres during ground works and measures to prevent site operatives being exposed to fibres within dust during redevelopment or excavations are recommended.

5.4 POTABLE WATER PIPE ASSESSMENT

If newly installed potable water pipes are proposed, a potable water pipe assessment may be required by the utility company to confirm appropriate construction materials.

5.5 CONTROLLED WATERS RISK ASSESSMENT

5.5.1 CONTROLLED WATERS SCREENING CRITERIA

Groundwater has been assessed using the appropriate water quality standards to provide protection to the underlying superficial deposits (Secondary Undifferentiated) and bedrock (Secondary B Aquifer). A secondary assessment using water quality standards protective of surface water has been completed to assess potential risk to the unnamed culverted river 440m northwest (possibly Corn Brook).

Based on the 'prevent and limit' approach of the Water Framework Directive (2000/60/EC) and the identified receptors, the following Water Quality Standards have been adopted:

- Water Supply (Water Quality) Regulations 2000 – UK DWS;
- The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 – EQS;
- Surface Waters (Dangerous Substances) (Classification) Regulations 1998 – UK EQS;
- Surrogate indicator compounds (used as proxy standards for compounds of similar chemical attributes and toxicity); and,
- International Standards (European Council Directive, WHO, USEPA, Surface Water Abstraction Directive) – appropriate for the receptor and in accordance with the UK approach.

The screening of water samples from BH1 and BH2 (round 2) is presented in Appendix H.

There are no GAC exceedances for petroleum hydrocarbons, BTEX and PAH compounds (with the exception of fluoranthene) in either sample. Several metal concentrations exceed the respective GAC. A list of exceedances is presented in Table 7. However, the exceedances are not considered to pose a risk to controlled waters receptors based on the discussion on 5.5.2.

N.B. Given the high sediment content of the samples collected during sampling round 1; these samples are not considered to be representative and have therefore been excluded from the Controlled Waters GQRA.

Table 7: Groundwater Exceedances – Round 2

Analyte	Screening Value (GAC) that has been exceeded (µg/l)		Monitoring Location	Concentration (µg/l)
	DWS	EQS		
Metals				
Arsenic	10	-	BH2	15.1
Cadmium	-	0.080	BH1 BH2	0.51 1.14
Chromium	50	4.70	BH1 BH2	30.4 79.1
Copper	-	1.00	BH1 BH2	24.6 69.0
Lead	10	1.20	BH1 BH2	13.5 38.7
Mercury	-	0.070	BH2	0.10
Nickel	20	4.00	BH1 BH2	52.2 104
Zinc	-	10.9	BH1 BH2	134 177
Polyaromatic Hydrocarbons				
Fluoranthene	-	0.006	BH2	0.027

5.5.2 CONTROLLED WATERS DISCUSSION

Whilst the controlled waters GQRA does highlight some GAC exceedances, the overall risk profile with regards to controlled waters receptors is considered to be low, based on the following considerations:

- The exceedances of the GQRA are all for non-volatile metals and a single PAH compound (fluoranthene) which exhibit general low mobility within groundwater.
- The site is within an SPZ III and no groundwater abstractions are recorded within 500m of the site indicating groundwater is not utilised in the vicinity of the site.
- Given the likely thickness of low permeability superficial clay (Glacial Till) vertical and lateral migration of groundwater is likely to be limited.

5.6 GROUND GAS RISK ASSESSMENT

Four ground gas monitoring visits were completed on 6 and 28 September and 5 and 10 October 2018 to provide an initial assessment of the ground gas regime at the site.

A summary of ground gas monitoring results is presented in Table 8.

Table 8: Ground Gas Monitoring Results

Borehole ID	Methane (% v/v)		Carbon Dioxide (% v/v)		Oxygen (% v/v)		Flow (l/hr)		Barometric Pressure range (mB)
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
BH1	<0.1	<0.1	0.1	0.3	19.6	20.3	<0.1	<0.1	1006 – 1024
BH2	<0.1	<0.1	0.3	0.8	17.4	18.9	<0.1	<0.1	1006 – 1024
BH3	<0.1	<0.1	0.2	0.5	19.6	20.4	<0.1	<0.1	1006 – 1024

The following maximum concentrations were recorded during the monitoring visits:

- Methane: <0.1% v/v
- Carbon Dioxide: 0.8% v/v
- Flow Rate: 0.0l/hr (a flow rate of 0.1l/hr has been assumed for this risk assessment)

The ground gas results have been used to generate a worst-case gas screening value (GSV) for the site based on the CIRIA C665. The GSV is the maximum volume of methane and carbon dioxide that would be produced each hour and is calculated as follows:

- GSV = Maximum steady carbon dioxide or methane (%) / 100 x max. steady flow rate.
- Carbon Dioxide = 0.0008
- Based on the CIRIA C665 guidance the GSV classifies the site as Characteristic Situation 1, whereby no gas protection measures are required.

If undertaking any future ground gas monitoring, consideration should be given to completing it during a period of falling low pressure (<1000mB) which would represent worst case conditions.

6 REVISED CONCEPTUAL SITE MODEL

The potentially complete pollutant linkages described in the preliminary CSM (presented in Section 2.3), have been re-assessed based on the results of the WSP site investigation and the generic quantitative risk assessment. A risk rating in accordance to the methodology described in CIRIA C552 (included in Appendix I) has also been included. The re-assessment is presented in Table 9.

Table 9: Revised Conceptual Site Model

POTENTIALLY COMPLETE POLLUTANT LINKAGE	COMMENT FOLLOWING GROUND INVESTIGATION AND RISK RATING
DURING REDEVELOPMENT	
Human health risks to ground workers and third parties (neighbours) associated with possible inhalation of asbestos fibres released during Made Ground excavation.	**LOW RISK:** Asbestos not identified but could be present in Made Ground. Precautions to limit dust recommended during construction.
Human health risks to ground workers associated with direct contact/ingestion/inhalation of chemical contamination and / or ground gases.	**LOW RISK:** No visual or olfactory evidence of soil contamination and no chemical contaminants in soil samples analysed with concentrations exceeding of the GAC.
AFTER REDEVELOPMENT	
Potential risks to future site users and maintenance workers from inhalation of volatile contamination or hazardous ground gases, if present.	**LOW RISK:** No soil samples with volatile chemical contamination above the LOD. No organic Made Ground or putrescible material identified during site investigation. Ground gas monitoring indicates the site is characteristic situation 1.
Potential risks to future site users if new potable water pipes are laid in contaminated soils.	**LOW RISK:** Chemical concentrations within soil samples were generally low, however utility provider may require a pipe risk assessment to confirm the suitable construction material.
Migration of mobile contamination to wider groundwater body and surface waters.	**LOW RISK:** A limited number of chemical contaminants of low mobility and toxicity exceeded the GAC combined. However, this combined with a low energy environment, low permeability (clay) and low sensitivity (absence of downgradient abstractions) environment is consistent with a low risk setting.
Volatilisation of groundwater vapour followed by inhalation	**VERY LOW RISK:** No light non-aqueous phase liquid recorded on groundwater within any of the wells and no volatile contaminants recorded in groundwater samples.
Potential risks to foundations from direct contact with aggressive ground conditions.	**LOW RISK:** Low risk if appropriate concrete is used during construction, AC-1 is suggested for the design of buried concrete.

7 GROUND CONDITIONS AND MATERIAL PROPERTIES

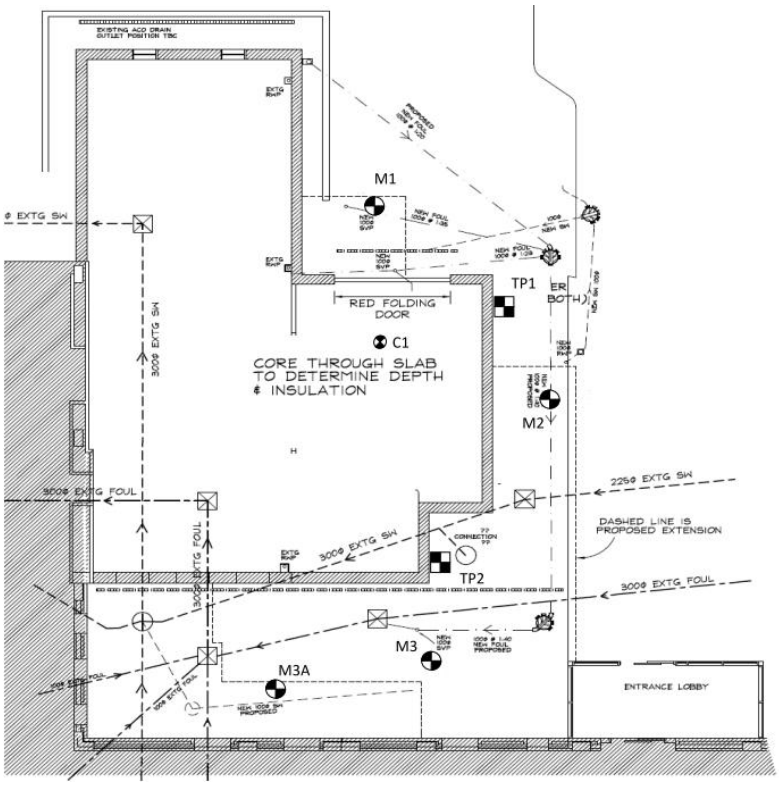
7.1 MADE GROUND

The 2018 investigation encountered an upper layer of asphalt and concrete surfacing up to 0.34m thick in all boreholes. Below the surfacing, Made Ground comprising a sandy limestone gravel (subbase) was encountered to depths of between 0.6m (BH2) and 2.1m bgl (BH1). A single SPT test was undertaken in the Made Ground, which gave an N_{60} value of 4, indicating the material to be very loose/loose.

BH3 recorded 0.25m of limestone gravel overlying 1.7m of sandy gravelly clay.

Boreholes undertaken by Sub Surface for the recent adjacent RESUS Unit extension and detailed in their report dated January 2015 [1] have been reviewed. Of the four boreholes undertaken, two (M1 & M2) recorded Glacial Till within 1m of ground level, with the remaining boreholes (M3 and M3A) recording in excess of 1.8 and 3.8m of Made Ground (predominantly sandy, sandstone gravel). An extract of Sub Surface's exploratory hole location plan is presented as Inset 1.

Inset 1: Extract of Sub Surface borehole location plan from Report No. 5971



1 Sub Surface. 2015. *Technical report: Ground investigation at A&E Manchester Royal Infirmary, Oxford Road, Manchester for Cofely FM Limited*. Report No. 5971

SPTs in M3 and M3A recorded *N* values between 3 and 7, suggesting very loose to loose conditions.

Sub Surface conclude that the deep Made Ground recorded is likely associated with a deep drain, which is possibly the 300mm diameter foul sewer shown on Inset 1. This sewer is understood to run under the proposed new structures, although its full route is not indicated on the current services drawing.

Due to the limited testing data and inherent variability, characteristic parameters have not been derived for the Made Ground.

7.2 GLACIAL TILL

Cohesive Glacial Till was recorded underlying the Made Ground in WSP boreholes BH1, BH2 and BH3 and Sub Surface boreholes M1, and M2, and comprised firm to stiff friable silty gravelly clay.

The base of the Glacial Till was proven in BH1 and BH2 at 12m bgl and 11.95m bgl respectively. A layer of clayey fine and medium gravel was recorded in BH1 between 11.75 and 12.00m bgl and between 10.40 and 11.2m bgl in BH2.

In-situ and laboratory testing results for the Glacial Till are summarised in Table 100.

Table 10: Summary of In-Situ and Laboratory Testing - Glacial Till

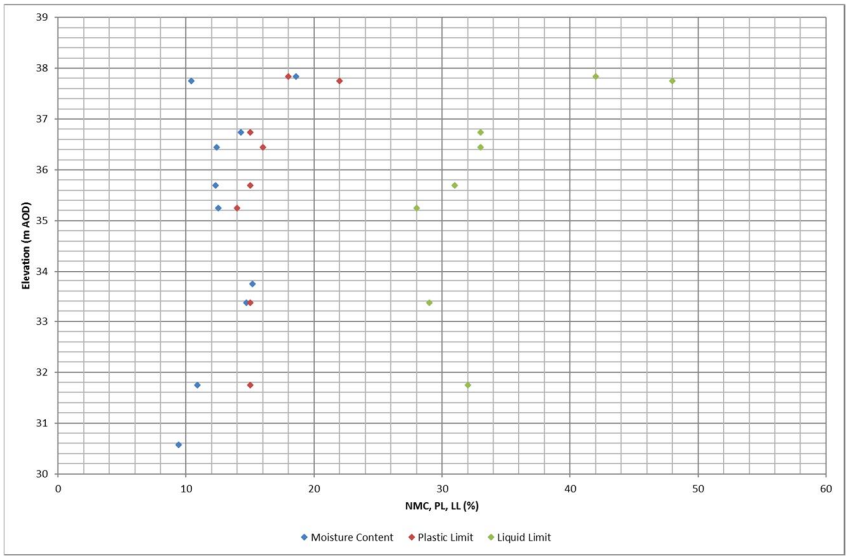
Parameter	No of Tests	Min – Max	Mean
SPT N_{60}*	20	15 – 155†	39
Undrained shear strength, c_u (kN/m^2) – laboratory triaxial	8	106 – 353	196
Moisture Content (%)	10	9 – 19	13
Liquid Limit (%)	9	22 – 48	33
Plastic Limit (%)		14 – 22	16
Plasticity Index (%)		6 – 26	17
Bulk Density (Mg/m^3)	8	2.09 – 2.27	2.21
Water soluble sulphate SO_4 (2:1) *mg/l)	Presented in Appendix D1		
pH	Presented in Appendix D1		

* corrected for hammer efficiency (assumed 60% for Sub Surface SPTs)
† includes extrapolated values

7.2.1 MOISTURE CONTENT & CLASSIFICATION TESTS

Inset 2 presents a plot of natural moisture content, plastic limit, and liquid limit versus elevation. The tests show the Glacial Till to be a clay of low to intermediate plasticity (Class CL to CI). One test appears to be anomalous, with a low liquid limit of 22%. This is considered to be due to a high granular content. Ignoring this sample, the moisture content, liquid limit, and plastic limit appear to decrease with increasing depth, with the moisture content generally below the plastic limit.

Inset 2: Natural Moisture Content, Plastic Limit, and Liquid Limit versus Elevation – Glacial Till



7.2.2 UNDRAINED SHEAR STRENGTH

The undrained shear strength, c_u was measured by laboratory triaxial testing and estimated from the following relationship with SPT N_{60}:

$c_u(kN/m^2) = f_1 N_{60}$ [2]

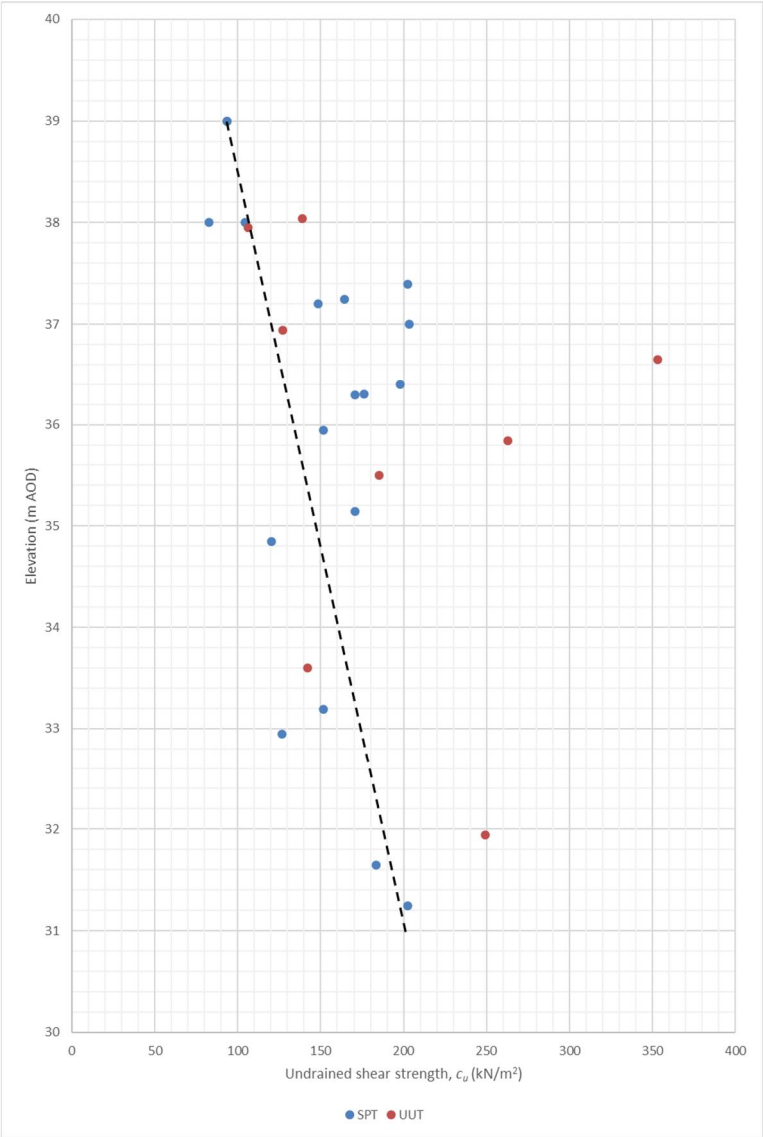
where *f1* is a factor related to the plasticity index, taken as 5.5 for a mean plasticity index of 17% [3].

The results of the triaxial testing and the above relationship are presented on Inset 3.

[2] Clayton, C.R.I. 1995. *The Standard Penetration Test (SPT): Methods and Use. CIRIA Report 143.* London: CIRIA

[3] Stroud, M.A. 1975. The standard penetration test in insensitive clays and soft rocks. *Proceedings of the European Symposium on Penetration Testing*. **2**. pp. 327-334

Inset 3: Undrained Shear Strength vs Elevation – Glacial Till



7.3 MANCHESTER MARLS FORMATION

Manchester Marls Formation was encountered underlying the Glacial Till at depths of 11.95m and 12m bgl.

Laboratory testing results for the Manchester Marls Formation are summarised in Table 11.

Table 11: Summary of Laboratory Testing - Manchester Marls Formation

Parameter	No. of Tests	Min – Max	Mean
Point Load Index, I_{S50} (MN/m^2)	2	0.04 & 0.05	0.045

7.3.1 UNCONFINED COMPRESSIVE STRENGTH

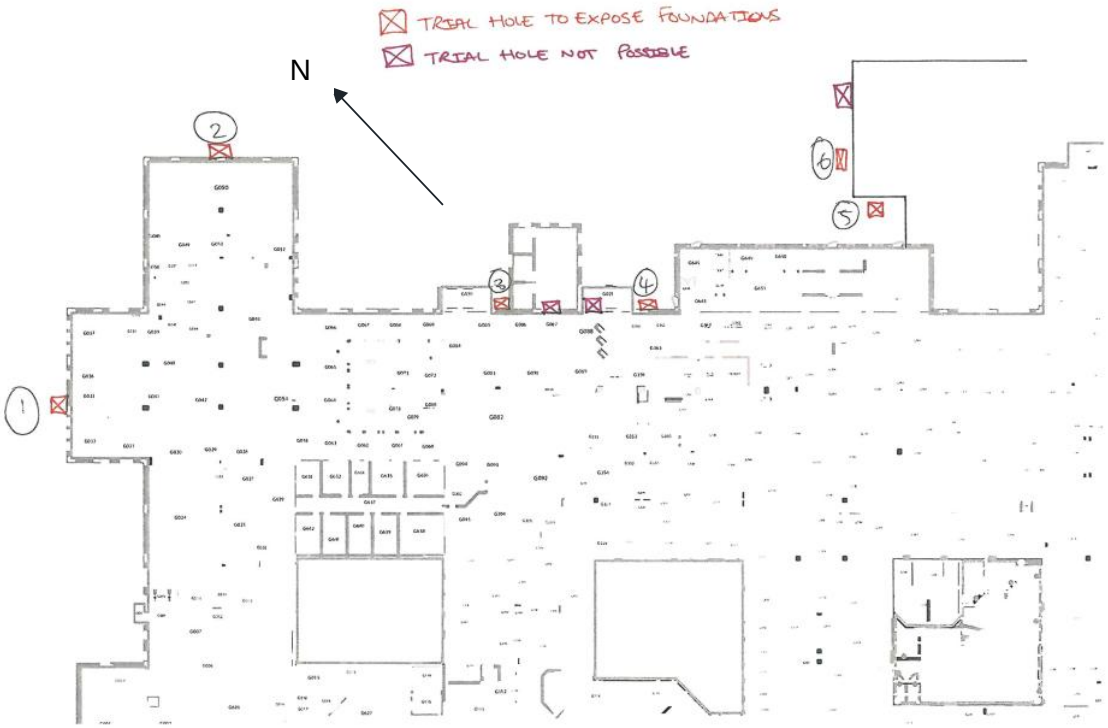
Conversion of the point load index, I_{S50} to an equivalent unconfined compressive strength (UCS) is generally achieved through the application of a correction factor, *K.* This is typically derived by correlating with direct UCS tests at equivalent depths. However, due to the highly fractured nature of the Manchester Marls Formation, very few samples were suitable for point load testing and no suitable samples could be selected for direct UCS testing.

Based on a conservative assessment of the limited point load test data and physical description, a UCS of 0.6MN/m^2 is considered appropriate for the Manchester Marls Formation.

7.4 EXISTING FOUNDATIONS

It is understood that the existing A&E building is founded on pad foundations. The two hand dug trial pits undertaken by Sub Surface (HD3 and HD4 in Appendix C), appeared to have encountered interconnecting ground beams, rather than the pads themselves. These were founded in Made Ground at depths of 0.75m and 0.65m respectively.

Inset 2: Sub Surface trial pit locations



HD5 and HD 6 were located on the elevation of the Radiology building, which is understood to be of load bearing masonry construction. HD5 encountered a concrete strip footing in excess of 1.2m deep, with a 0.33m projection. HD6 encountered a similar footing, with a 0.2m projection, and founded on stiff clay at a depth of 1.16m bgl.

HD1 was formed at the location of the proposed canopy on the northern elevation, and encountered what appeared to be a concrete ground beam founded in Made Ground at a depth of 0.46m.

Two trial pits were also undertaken by Sub Surface on the southern elevation of the Hospital building in 2015 (see Inset 1). These record a concrete foundation (either a strip, raft edge, or a ground beam) founded at depths of approximately 800mm to 900mm (exact founding depths not provided). These works supported the construction of an extension to the existing RESUS department, the foundations for which are unknown.

8 ENGINEERING ASSESSMENT

8.1 DEVELOPMENT PROPOSALS

The Project RED proposals are to extend the existing hospital building footprint out into the existing ambulance bays. The existing single-storey modular buildings (walk in centre) and the single storey RESUS extension will be demolished to make way for the new development. Two new and linked structures are proposed comprising:

- A two storey, steel framed structure linked to the existing hospital which will house the RESUS department on the ground floor and offices on the first floor. The structure will contain a new plantroom at roof level; and,
- A new Majors and Minors building. This will be a single storey steel framed construction that will be connected to the new RESUS structure and the existing hospital.
- A new entrance lobby on northern elevation of the existing hospital building will also be constructed.
- Floor levels for both structures will match the existing hospital.
- Maximum column loads for the Majors and Minors structure are understood to be in the region of 300kN. Column loads for the RESUS building are anticipated to be in the region of 900kN. The design floor loadings for both structures is 5kN/m^2.
- A new 9-bay ambulance and police parking area will be provided adjacent to the Majors and Minors building.

An extract of the development proposals is given in Inset 5.

Inset 5 - Extract of development proposals

The build programme is unclear, but it seems unlikely that both structures will be built at the same time.

8.2 GEOTECHNICAL CATEGORY

It is considered that the structures will fall within Geotechnical Category 2 as defined in BS EN 1997-1:2004 [4]. These are structures and foundations with no exceptional risk, difficult ground, or loading conditions.

A geotechnical risk register is presented in **Section 9.**

8.3 STRUCTURAL FOUNDATIONS & GROUND FLOOR SLABS

8.3.1 MAJORS AND MINORS BUILDING

Whilst the current investigation has encountered competent Glacial Till at depths that may be suitable for the use of conventional pad foundations, there is a risk that the foundation strategy may be compromised by areas of deep Made Ground associated with the existing drainage. Therefore, consideration should be given to the use of a semi rigid raft foundation with stiffened down stands. Column loads would be supported on the down stands and reinforcement should be designed to ensure that the bearing pressure does not exceed 75kN/m^2. Such a foundation should be designed to span 3m and cantilever 1.5m at the corners.

Following excavation to formation level, the formation shall be proof rolled with a heavy vibrating roller and inspected by a geotechnical engineer. Any soft spots encountered should be excavated and backfilled with, well graded granular fill, well compacted in thin layers. If obstructions are encountered, these should either be removed in their entirety, or if not practicable, broken down to a minimum of 1m below formation level. Any resulting voids, or low areas should be remediated as described above (refer to **Section 8.3.5** for additional commentary on obstructions).

A series of plate load tests should be undertaken on the completed formation using a 600mm diameter plate. A minimum deformation modulus of 5MPa (at working load) shall be achieved at formation level. If the ground is found to be poor or variable, then additional remedial works will need to be undertaken, which will likely comprise additional excavation and replacement.

The raft should be underlain by a minimum of 200mm of well compacted granular fill which, where practicable, should extend 0.5m beyond the raft edge.

Total settlements would be anticipated to be in the region of 10-15mm, the majority of which would be expected to occur as the loading is increased and therefore 'built out'. To avoid potential differential settlement effects at the interface with the hospital building, it would be advisable to incorporate an appropriate movement joint and lay floor finishes as late as practicable in the build process.

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[4] British Standards Institution. 2014. BS EN 1997-1:2004+A1:2013 *Incorporating corrigendum February 2009. Eurocode 7: Geotechnical design – Part 1: General rules.* London: BSI

There are clearly issues where new columns are required adjacent to the existing structure and it will likely be necessary to cantilever the columns on a widened down stand.

There will also need to be an interface between the structure and the new RESUS structure and this is discussed below.

8.3.2 RESUS

Column loads for the Reus unit are significantly higher than the Majors & Minors at approximately 900kN and foundations for the southern elevation are likely to be affected by the drain discussed above which, close to the structure, is indicated to have an invert level approximately 3.55m below current ground level.

The column loads are considered too high to allow the use of a raft foundation and excavating spread foundations to potentially circa 4m bgl adjacent to the existing structure is considered impractical. Given this, it is considered that a piled foundation is the most appropriate solution for the RESUS structure.

Based on the recorded ground conditions and proximity to existing buildings, the use of contractor designed continuous flight auger (CFA) piles is considered a potential solution. Rig clearance will dictate where piles can be placed and new columns will likely need to be cantilevered where adjoining the existing A&E and Radiology buildings.

The interface between ground beams for the RESUS unit and the adjacent Majors & Minors will need to be considered when the build program is established.

Whilst ground floor loadings are anticipated to be relatively low (circa 5kN/m^2), the slab will potentially be underlain locally by a significant depth of Made Ground. A ground bearing floor slab is considered feasible, provided that the formation (underside of piling platform if the top of the piling platform is set close to the underside of slab level) is prepared and validated as detailed for the raft foundation. Again, if the ground is found to be poor/variable then additional remedial works will be required, which will likely consist of additional excavation and replacement. Suspending the ground floor is an option, although this will likely prove costly.

8.3.3 ENTRANCE LOBBY

The lobby will be lightweight structure and it is considered that this may be founded on a raft, detailed as discussed above for the Majors and Minors building.

8.3.4 BELOW GROUND EXCAVATIONS

The stability of any Made Ground should not be relied upon in unsupported excavations. Zones loosened by demolition works may be particularly unpredictable and prone to collapse. Safe working conditions should be ensured at all times where persons are required to work in any excavations. This can be achieved by the use of ground support or battering back to a safe angle.

Excavations should be designed and formed such that they do not affect the stability of the existing hospital buildings. If excavations are perceived to pose a risk to the existing structures, underpinning or some other means of mitigating the risk may be required.

No significant problems are anticipated in forming excavations for foundations and ground beams, although pneumatic breakers may be required to breakout obstructions.

Groundwater should be anticipated within 3m of ground level and is considered unlikely to have significant effect on the works. Inflows of perched water may be encountered within the Made Ground and from any granular layers within the Glacial Till. Whilst such inflows are unlikely to be excessive, they may persistent (particularly during periods of wet weather) and may require the use of sump pumping.

The advice of a specialist should be sought when designing the temporary works. Further Reference should be made to CIRIA Report 97 [5].

8.3.5 OBSTRUCTIONS

Below ground obstructions associated with the current site and potentially previous site usages (foundations, services etc.) may have an adverse impact on the works (e.g. temporary works and foundation excavations). The risk of encountering obstructions during the ground works stage should be carefully considered and appropriate strategies put in place and allowances made in budget costings to mitigate their impact.

As a general rule, and where practicable, obstructions will require complete removal where they conflict with the proposed development. However, as discussed above, and subject to engineer approval, obstructions may be left insitu, provided that they will not clash with piles and are broken down a minimum of 1m below formation level.

It is understood that the existing drainage is to be decommissioned and any pipework left in the ground removed or grouted up.

Any manholes, if not removed, should be grouted up to a maximum of 1m below formation level, and any remnant structure removed.

The treatment of any resulting voids and low areas following obstruction removal is discussed in **Section 8.3.1**.

8.3.6 PAVEMENT DESIGN

Specific testing for pavement design was not undertaken during the investigation as, given the disturbance likely to be caused by the enabling works, such testing is unlikely to be representative of site conditions at construction stage.

Detailed specifications will need to be prepared to ensure that areas where obstructions are removed and any general backfilling are appropriately re-engineered (see general procedures in **Section 8.3.5**).

Specific California Bearing Ratio (CBR) testing will be required on completed subgrades to inform detailed pavement design and, at this stage, a CBR of less than 2.5% is considered appropriate. It is possible that higher values could be achieved with appropriate preparation of the subgrade.

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[5] Irvine, D.J. and Smith, R.J.H. 2001. *CIRIA Report 97: Trenching practice.* London: CIRIA.

8.3.7 CHEMICAL ATTACK ON BURIED CONCRETE

Based on the guidelines presented in BRE Special Digest 1 [6], a Design Sulphate Class of DS-1 and Aggressive Chemical Environment (ACEC) class of AC-1 is suggested for the design of buried concrete.

6 Building Research Establishment Construction Division. 2005. *Special Digest 1: Concrete in aggressive ground*. 3rd edition. Watford: IHS BRE Press

9 GEOTECHNICAL RISK REGISTER

A preliminary Geotechnical Risk Register for the scheme is presented in Table 12.

Table 12: Preliminary Geotechnical Risk Register

Hazard	Cause	Consequence	Level of Risk Without Control	Control Adopted	Risk Ownership
Unforeseen ground conditions	Ground conditions differ from those assumed within the design	Delays on site Possible re-design of foundations, retaining structures etc. Financial implications	High	Desk based study and intrusive investigation undertaken to inform the ground model and facilitate design. Note: ground investigation only samples a limited amount of the ground and conditions may exist between exploratory holes that are not identified by the ground investigation and cannot be anticipated from interpretation of the available data. As such, the risk of unforeseen ground conditions cannot be entirely mitigated	Client
Excessive total and differential settlement of raft foundation	Poor preparation of formation	Damage to structure Remedial works required Financial implications	Moderate	Formation to be adequately prepared and validated Formation to be inspected by a suitably qualified and experienced geotechnical engineer. Allowance to be made for additional excavation if ground conditions are not as assumed. Design to be based on a conservative assessment of ground conditions.	Contractor and Designer

Hazard	Cause	Consequence	Level of Risk Without Control	Control Adopted	Risk Ownership
Excessive total and differential settlement of ground bearing floors	Poor preparation of formation	Damage to structure Remedial works required Financial implications	Moderate	Formation to be adequately prepared and validated Formation to be inspected by a suitably qualified and experienced geotechnical engineer. Allowance to be made for additional excavation if ground conditions are not as assumed. Design to be based on a conservative assessment of ground conditions	Contractor and Designer
Bearing piles fail to provide adequate capacity	Inappropriate assessment of ground investigation data	Additional piles may be required Financial implications Delays on site	Low / moderate	Pile design to be undertaken by a competent contractor based on their own conservative assessment of the ground investigation data Pile testing to be incorporated at an early stage	Piling Contractor

Hazard	Cause	Consequence	Level of Risk Without Control	Control Adopted	Risk Ownership
Piles fail to reach design depth	Obstructions Ground strength greater than anticipated Use of an inappropriate rig	Additional piles may be required Financial implications Delays on site	High	Appropriate measures to be put in place to mitigate the risk as much as practicable prior to construction. Piling contractor to be aware of the risk of obstructions within the Made Ground and the Glacial Till and likely rock strength. Pile design to be undertaken by a competent contractor based on their own conservative assessment of the ground investigation data. Use of an appropriate piling rig.	Piling Contractor
Differential settlement effects between interface of existing building and new building	Settlement of new foundations	Damage to structure Remedial works required Financial implications	Moderate	Appropriate preparation, inspection and validation of formation Incorporate appropriate movement joint. Lay floor finishes as late as practicable	Contractor
Damage to existing buildings	Works undermine existing foundations	Damage to structure Remedial works required Financial implications	Moderate	Use of underpinning, or other methods to ensure adequate support of the existing structure	Contractor

Hazard	Cause	Consequence	Level of Risk Without Control	Control Adopted	Risk Ownership
Poor performance of external areas	Poor preparation of formation Inadequate design	Remedial works required Financial implications	Moderate	Formation to be adequately prepared and validated Pavement design to suit subgrade strength	Contractor and Designer
Collapse of excavations Damage to adjacent structures and infrastructure	Insufficient ground support, poor design of batters / ground support	Health and safety implications Financial implications Delays on site	High	Temporary works to be appropriately designed to take into account ground stability, groundwater level, loading, and proximity and nature of site boundaries. Stability to be ensured by competent design and use of ground support, appropriate safe batters, or underpinning.	Contractor
Difficult excavation	Obstructions in the Made Ground	Financial implications Delays on site	High	A detailed strategy for obstruction removal should be implemented to ensure that abnormal costs are appropriately managed	Contractor
Excessive groundwater ingress into excavations	Groundwater levels higher than currently anticipated	Health and safety implications Delays to programme	Low	Allowance to be made for dewatering during excavations. Dewatering works to be assessed and designed by a competent specialist contractor.	Contractor and Designer

Hazard	Cause	Consequence	Level of Risk Without Control	Control Adopted	Risk Ownership
Toppling of piling rig	Failure of working platform	Health and safety implications Reputational damage	High	Platform to be designed and maintained in accordance with current good practice	Piling Contractor and Contractor
Damage to services	Inappropriate buried services assessment	Delays Health and safety issues Financial / legal implications	High	Undertake appropriate services search and undertake diversion/disconnection where necessary	Contractor
Degradation of below ground concrete	Inappropriate concrete assessment	Remedial works required Financial implications	Moderate	Undertake sufficient number of sulphate and pH tests Appropriate assessment of groundwater activity	Designer

Hazard	Cause	Consequence	Level of Risk Without Control	Control Adopted	Risk Ownership
Exposure to contaminated soils	Asbestos and unforeseen contamination	Health and Safety implications	Low to Moderate	Contractor to prepare Health and Safety documentation. Adoption of appropriate PPE e.g. gloves, overalls. Watching brief should be undertaken during construction as it is possible that additional areas of localised contamination may be encountered during site preparation work	Contractor

10 CONCLUSIONS

10.1 CONCLUSIONS

10.1.1 ENVIRONMENTAL

The assessment of contamination was based on a targeted ground investigation, laboratory testing and completion of a Generic Quantitative Risk Assessment. The following conclusion have been reached:

- The investigation identified no chemical contamination concentrations within the soil samples analysed that exceeded the GAC and therefore did not identify potentially unacceptable risks to human health receptors.
- Any potential risks to ground workers during redevelopment should be managed through appropriate good hygiene practices and use of personal protective equipment.
- The low sensitivity environmental site setting means although there are a number of exceedances of the controlled waters GAC in groundwater samples, an unacceptable risk to controlled waters is not considered to be present.
- Based on the ground gas regime established during monitoring gas protection measures will not be required in the new buildings.
- If newly installed potable water pipes are to be installed a potable water pipe risk assessment may be required by the utility company to establish appropriate construction materials.
- The overall risk profile with regards to the redevelopment of the site, for it to continue as a commercial usage (hospital A&E) is considered to be low to very low risk.

10.1.2 GEOTECHNICAL

- The ability to use spread foundations for the proposed structures is considered likely to be compromised by areas of deep Made Ground, likely associated with an existing sewer.
- Based on the indicated structural loadings, it is considered that the Majors and Minors building may be founded on a raft foundation, provided that the formation is adequately prepared and validated.
- Plied foundations are considered to be required for the RESUS building. A ground bearing floor may be considered subject to adequate formation preparation and validation.
- The proposed canopy on the on the northern elevation of the hospital building may be founded on a raft foundation.
- Ground stability is considered a risk and appropriate ground support will be required for all excavations.
- If it is considered that the works may undermine the existing structure, then underpinning may be required.
- Below ground may have an adverse impact on the works and appropriate strategies put in place and allowances made in budget costings to mitigate their impact.
- A California Bearing Ratio of less than 2.5% is considered appropriate for preliminary design.
- Below ground concrete may be designed in accordance with DS-1 and AC-1.

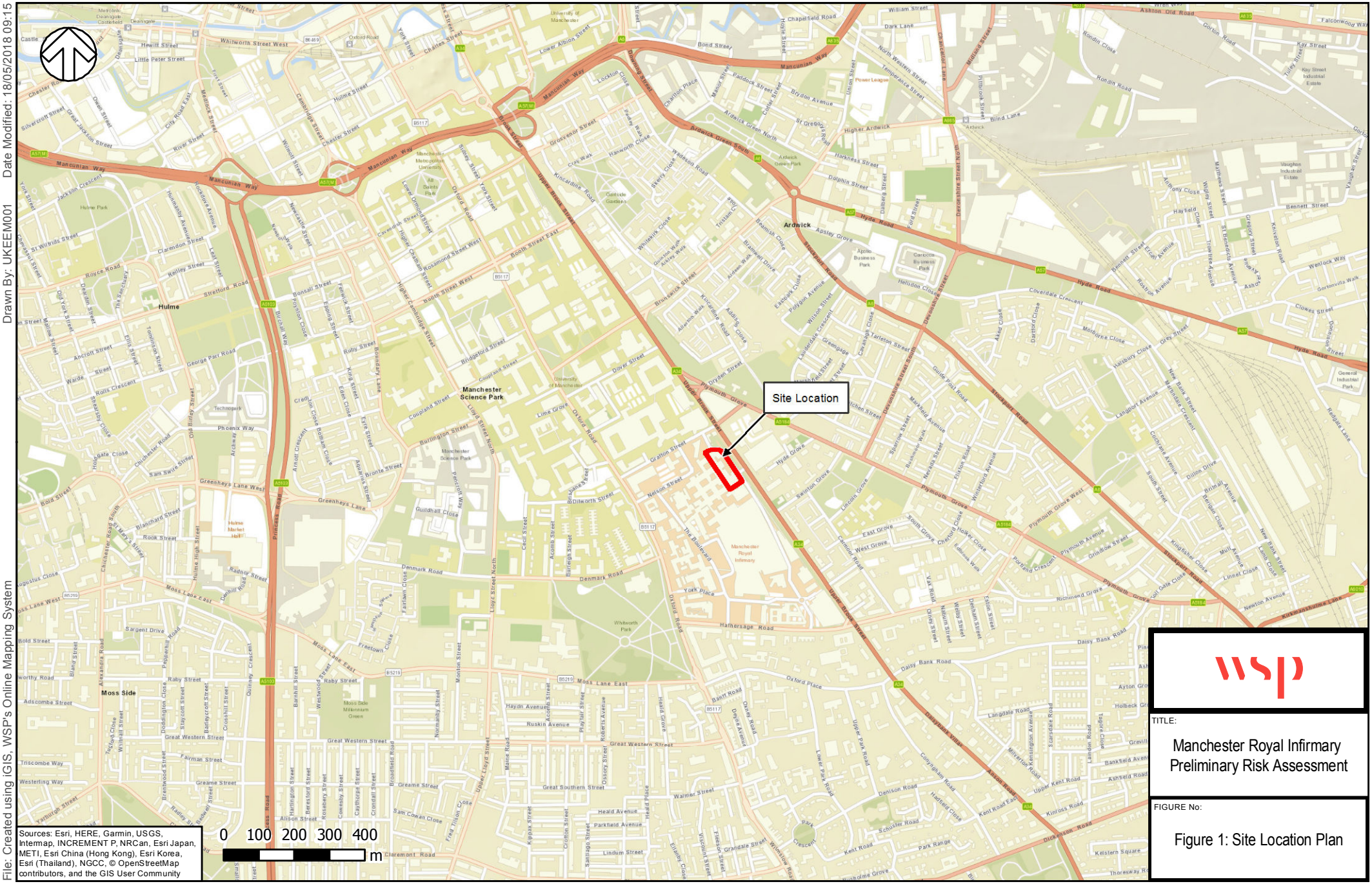
10.2 RECOMMENDATIONS

Additional intrusive assessment is not considered to be required prior to redevelopment as per the proposed designs seen by WSP.

Should unexpected contamination be encountered during the redevelopment then works should cease whilst the risk is reappraised by an appropriately trained environmental consultant.

Appendix A

FIGURES & DRAWINGS



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

File: Created using iGIS, WSP's Online Mapping System Drawn By: UKEEM001 Date Modified: 18/05/2018 09:15

wsp

TITLE:

Manchester Royal Infirmary
Preliminary Risk Assessment

FIGURE No:

Figure 1: Site Location Plan

Date Modified: 12/09/2018

Drawn By: UKEEM001

File: Q:\WSP_UK\WSP_Egint\#Projects\Agresso\70048625 - Project RED (MRI)\ArcGIS\2018 Figure 2 Site Features and BH Location.mxd

Key

- WSP 2018 Rotary Boreholes
- WSP 2018 Hand Held Window Sample Borehole
- Site Boundary
- A&E Walk-In Centre
- RESUS
- Ambulance Parking Bays
- General Clinic Area

BH1

BH2

BH3

Contains Ordnance Survey data © Crown copyright and database right 2018.

0 4.5 9 13.5 18

Metres

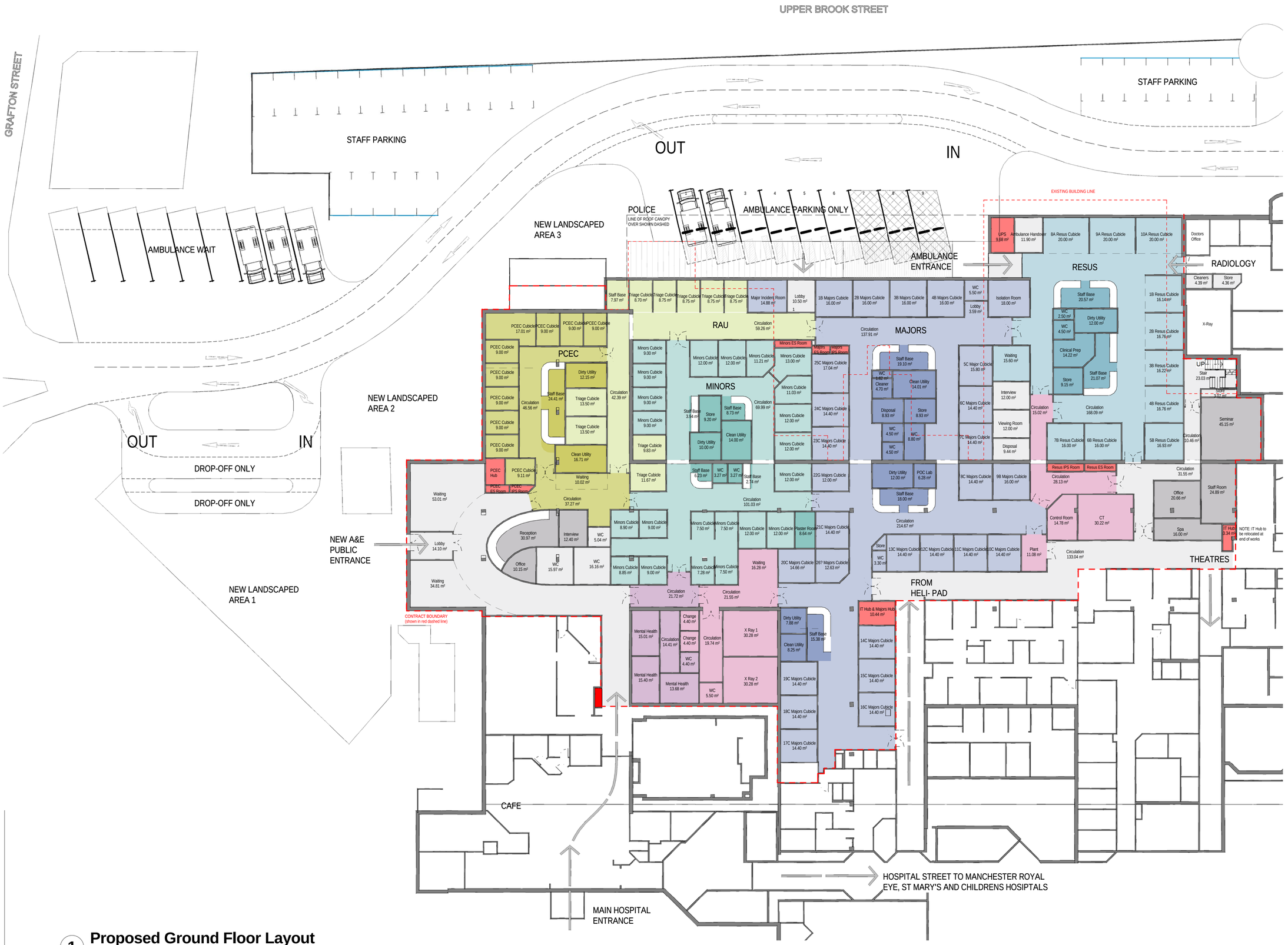
wsp

TITLE:

70048625
PROJECT RED

FIGURE No:

FIGURE 2
SITE FEATURES AND
BOREHOLE LOCATION
PLAN



GROUND DEPARTMENT AREAS		
Department	Nett Area	Gross Area
ANCILLARY	549.77 m²	579.21 m²
ED ADMIN	160.21 m²	169.31 m²
MAJORS	923.25 m²	991.56 m²
MENTAL HEALTH	84.61 m²	94.66 m²
MINORS	461.81 m²	504.31 m²
PCEC	245.24 m²	270.61 m²
PLANT	55.39 m²	52.56 m²
RADIOLOGY	231.66 m²	307.78 m²
RAU	193.06 m²	209.24 m²
RESUS	442.50 m²	466.02 m²
TOTAL	3347.51 m²	3645.26 m²

DEPARTMENT

- ANCILLARY
- ED ADMIN
- MAJORS
- MAJORS BASE
- MENTAL HEALTH
- MINORS
- MINORS BASE
- PCEC
- PCEC BASE
- PLANT
- RADIOLOGY
- RAU
- RESUS
- RESUS BASE
- CONTRACT BOUNDARY

REVISION	DATE	DESCRIPTION	ARCHITECT	PARTNER
S1-P 1	23/10/17	First Issue	ADP	

CHECK ALL DIMENSIONS AND VERIFY ON SITE. REPORT ANY ERRORS OR OMISSIONS

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JOB TITLE:
PROJECT RED
A&E DEPARTMENT
MANCHESTER ROYAL INFIRMARY

DRAWING TITLE:
GROUND FLOOR - GENERAL ARRANGEMENT PLAN

SCALE:	DRAWING SHEET SIZE:
1 : 200	A1

JOB CODE:	DRAWING NUMBER:	REVISION:
CMFT1	ADP-00-00-DR- A-1025	S1-P 1

1 Proposed Ground Floor Layout

1 : 200

This line should measure 100mm along x and y axis when printed

Appendix B

GENERAL LIMITATIONS

REPORT LIMITATIONS - GROUND RISK AND REMEDIATION

GENERAL

1. WSP UK Limited has prepared this report solely for the use of the Client and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed and outlined in the body of the report.

2. Unless explicitly agreed otherwise, in writing, this report has been prepared under WSP UK Limited standard Terms and Conditions as included within our proposal to the Client.

3. Project specific appointment documents may be agreed at our discretion and a charge may be levied for both the time to review and finalise appointments documents and also for associated changes to the appointment terms. WSP UK Limited reserves the right to amend the fee should any changes to the appointment terms create an increase risk to WSP UK Limited.

4. The report needs to be considered in the light of the WSP UK Limited proposal and associated limitations of scope. The report needs to be read in full and isolated sections cannot be used without full reference to other elements of the report and any previous works referenced within the report.

PHASE 1 GEO ENVIRONMENTAL AND PRELIMINARY RISK ASSESSMENTS

Coverage: *This section covers reports with the following titles or combination of titles: phase 1; desk top study; geo environmental assessment; development appraisal; preliminary environmental risk assessment; constraints report; due diligence report; geotechnical development review; environmental statement; environmental chapter; project scope summary report (PSSR), program environmental impact report (PEIR), geotechnical development risk register; and, baseline environmental assessment.*

5. The works undertaken to prepare this report comprised a study of available and easily documented information from a variety of sources (including the Client), together with (where appropriate) a brief walk over inspection of the Site and correspondence with relevant authorities and other interested parties. Due to the short timescales associated with these projects responses may not have been received from all parties. WSP UK Limited cannot be held responsible for any disclosures that are provided post production of our report and will not automatically update our report.

6. The opinions given in this report have been dictated by the finite data on which they are based and are relevant only for the purpose for which the report was commissioned. The information reviewed should not be considered exhaustive and has been accepted in good faith as providing true and representative data pertaining to site conditions. Should additional information become available which may affect the opinions expressed in this report, WSP UK Limited reserves the right to review such information and, if warranted, to modify the opinions accordingly.

7. It should be noted that any risks identified in this report are perceived risks based on the information reviewed. Actual risks can only be assessed following intrusive investigations of the site.

8. WSP UK Limited does not warrant work / data undertaken / provided by others.

REPORT LIMITATIONS - GROUND RISK AND REMEDIATION

INTRUSIVE INVESTIGATION REPORTS

Coverage: *The following report titles (or combination) may cover this category of work: geo environmental site investigation; geotechnical assessment; GIR (Ground Investigation reports); preliminary environmental and geotechnical risk assessment; and, geotechnical risk register.*

9. The investigation has been undertaken to provide information concerning either:

- **i.** The type and degree of contamination present at the site in order to allow a generic quantitative risk assessment to be undertaken; or
- **ii.** Information on the soil properties present at the site to allow for geotechnical development constraints to be considered.

10. The scope of the investigation was selected on the basis of the specific development and land use scenario proposed by the Client and may be inappropriate to another form of development or scheme. If the development layout was not known at the time of the investigation the report findings may need revisiting once the development layout is confirmed.

11. For contamination purposes, the objectives of the investigation are limited to establishing the risks associated with potential contamination sources with the potential to cause harm to human health, building materials, the environment (including adjacent land), or controlled waters.

12. For geotechnical investigations the purpose is to broadly consider potential development constraints associated with the physical property of the soils underlying the site within the context of the proposed future or continued use of the site, as stated within the report.

13. The amount of exploratory work, soil property testing and chemical testing undertaken has necessarily been restricted by various factors which may include accessibility, the presence of services; existing buildings; current site usage or short timescales. The exploratory holes completed assess only a small percentage of the area in relation to the overall size of the Site, and as such can only provide a general indication of conditions.

14. The number of sampling points and the methods of sampling and testing do not preclude the possible existence of contamination where concentrations may be significantly higher than those actually encountered or ground conditions that vary from those identified. In addition, there may be exceptional ground conditions elsewhere on the site which have not been disclosed by this investigation and which have therefore not been taken into account in this report.

15. The inspection, testing and monitoring records relate specifically to the investigation points and the timeframe that the works were undertaken. They will also be limited by the techniques employed. As part of this assessment, WSP UK Limited has used reasonable skill and care to extrapolate conditions between these points based upon assumptions to develop our interpretation and conclusions. The assumption made in forming our conclusions is that the ground and groundwater conditions (both chemically and physically) are the same as have been encountered during the works undertaken at the specific points of investigation. Conditions can change between investigation points and these interpretations should be considered indicative.

16. The risk assessment and opinions provided are based on currently available guidance relating to acceptable contamination concentrations; no liability can be accepted for the retrospective effects of any future changes or amendments to these values. Specific assumptions associated

with the WSP UK Limited risk assessment process have been outlined within the body or associated appendix of the report.

17. Additional investigations may be required in order to satisfy relevant planning conditions or to resolve any engineering and environmental issues.

18. Where soil contamination concentrations recorded as part of this investigation are used for commentary on potential waste classification of soils for disposal purposes, these should be classed as indicative only. Due consideration should be given to the variability of contaminant concentrations taken from targeted samples versus bulk excavated soils and the potential variability of contaminant concentrations between sampling locations. Where major waste disposal operations are considered, targeted waste classification investigations should be designed.

19. The results of the asbestos testing are factually reported and interpretation given as to how this relates to the previous use of the site, the types of ground encountered and site conceptualisation. This does not however constitute a formal asbestos assessment. These results should be treated cautiously and should not be relied upon to provide detailed and representative information on the delineation, type and extent of bulk ACMs and / or trace loose asbestos fibres within the soil matrix at the site.

20. If costs have been included in relation to additional site works, and / or site remediation works these must be considered as indicative only and must be confirmed by a qualified quantity surveyor.

EUROCODE 7: GEOTECHNICAL DESIGN

21. On 1st April 2010, BS EN 1997-1:2004 (Eurocode 7: Geotechnical Design – Part 1) became the mandatory baseline standard for geotechnical ground investigations.

22. In terms of geotechnical design for foundations, slopes, retaining walls and earthworks, EC7 sets guidance on design procedures including specific guidance on the numbers and spacings of boreholes for geotechnical design, there are limits to methods of ground investigation and the quality of data obtained and there are also prescriptive methods of assessing soil strengths and methods of design. Unless otherwise explicitly stated, the work has not been undertaken in accordance with EC7. A standard geotechnical interpretative report will not meet the requirements of the Geotechnical Design Report (GDR) under Eurocode 7. The GDR can only be prepared following confirmation of all structural loads and serviceability requirements. The report is likely to represent a Ground Investigation Report (GIR) under the Eurocode 7 guidance.

DETAILED QUANTITATIVE RISK ASSESSMENTS AND REMEDIAL STRATEGY REPORTS

23. These reports build upon previous report versions and associated notes. The scope of the investigation, further testing and monitoring and associated risk assessments were selected on the basis of the specific development and land use scenario proposed by the Client and may not be appropriate to another form of development or scheme layout. The risk assessment and opinions provided are based on currently available approaches in the generation of Site Specific Assessment Criteria relating to contamination concentrations and are not considered to represent a risk in a specific land use scenario to a specific receptor. No liability can be accepted for the retrospective effects of any future changes or amendments to these values, associated models or associated guidance.

REPORT LIMITATIONS - GROUND RISK AND REMEDIATION

24. The outputs of the Detailed Quantitative Risk Assessments are based upon WSP UK Limited manipulation of standard risk assessment models. These are our interpretation of the risk assessment criteria.

25. Prior to adoption on site they will need discussing and agreeing with the Regulatory Authorities prior to adoption on site. The regulatory discussion and engagement process may result in an alternative interpretation being determined and agreed. The process and timescales associated with the Regulatory Authority engagement are not within the control of WSP UK Limited. All costs and programmes presented as a result of this process should be validated by a quantity surveyor and should be presumed to be indicative.

GEOTECHNICAL DESIGN REPORT (GDR)

26. The GDR can only be prepared following confirmation of all structural loads and serviceability requirements. All the relevant information needs to be provided to allow for a GDR to be produced.

MONITORING (INCLUDING REMEDIATION MONITORING REPORTS)

27. These reports are factual in nature and comprise monitoring, normally groundwater and ground gas and data provided by contractors as part of an earthworks or remedial works.

28. The data is presented and will be compared with assessment criteria.

Appendix C

EXPLORATORY HOLE RECORDS

WSP The Victoria, 150-182 The Quays Salford Quays, M50 3SP Telephone: +44 (0)161 886 2400	**BOREHOLE LOG**	Hole No. **BH1**
	Project Project RED	Sheet 1 of 3
Job No 70048625	Client ENGIE Buildings Limited	Date 20-08-18 24-08-18

Contractor / Driller	Method/Plant Used	Logged By	Co-Ordinates (NGR)	Ground Level (m AOD)
Geotron UK Ltd	Comacchio 350	EM/RH	E 385106.388 N 396327.829	40.118

SAMPLES & TESTS							STRATA					
Depth	Type	Test Result	PID (ppmV)	HSV (kN/m2)	P.Pen (kN/m2)	Water	Elev. (mAOD)	Depth (Thick-ness)	Description	Legend	Geology	Install / Backfill Dia. 50 mm
							40.02	0.10	ASPHALT		TARMAC	
							39.96	0.16	CONCRETE		CONC	
0.20-0.30	ES		0.0					(0.54)	Light brown gravelly coarse SAND. Gravel is angular, fine to coarse and of limestone. (SUBBASE) (MADE GROUND).		GMG	
							39.42	0.70				
0.80-0.90	ES		0.0						Grey gravelly coarse SAND. Gravel is angular, fine to coarse and of limestone. (SUBBASE) (MADE GROUND).			
1.50	SPT	1,1,2 1,0,1 N=4(S)	0.0					(1.40)			GMG	
							38.02	2.10				
2.20-2.30	ES		0.0						Firm to stiff brown mottled grey friable silty gravelly CLAY with visible decaying organic matter (roots). Gravel is angular to subangular, fine to medium and of coal and various lithologies. (GLACIAL TILL).			
2.50-2.95	U											
2.95-3.15	B											
3.15	SPT	2,4,6 7,8,11 N=32(S)	0.0					(2.40)			TILL	
3.15-3.60	B											
3.40-3.50	ES											
3.60-4.05	U		0.0									
4.05-4.25	B											
4.25	SPT	3,3,5 7,7,8 N=27(S)	0.0									
							35.62	4.50				
4.25-4.70	B								Firm to stiff brown gravelly silty CLAY. Gravel is rounded, fine to coarse of various lithologies. Rare 3mm to 6mm lenses of fine orange sand between 4.5m to 6.5m bgl. Occassional silt/sand bands.			
4.70-5.15	U											
5.15-5.40	B		0.0								TILL	
5.40	SPT	3,3,4 6,8,9 N=27(S)										

DRAFT

Boring Progress						Water Strikes					
Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt	Date	Time	Strike	Minutes	Standing	Casing

Chiselling				Water Added		General Remarks
From	To	Hours	Tool	From	To	

Scale 1:37.5	Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.

WSP
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Salford Quays, M50 3SP
Telephone: +44 (0)161 886 2400

BOREHOLE LOG

Hole No. **BH1**

Project: Project RED

Sheet: 2 of 3

Job No	Client	Date
70048625	ENGIE Buildings Limited	20-08-18 24-08-18

Contractor / Driller	Method/Plant Used	Logged By	Co-Ordinates (NGR)	Ground Level (m AOD)
Geotron UK Ltd	Comacchio 350	EM/RH	E 385106.388 N 396327.829	40.118

SAMPLES & TESTS							STRATA					Install / Backfill
Depth	Type	Test Result	PID (ppmV)	HSV (kN/m2)	P.Pen (kN/m2)	Water	Elev. (mAOD)	Depth (Thick-ness)	Description	Legend	Geology	Dia. 50 mm
6.00-6.50	B		0.0						Firm to stiff brown gravelly silty CLAY. Gravel is rounded, fine to coarse of various lithologies. Rare 3mm to 6mm lenses of fine orange sand between 4.5m to 6.5m bgl. Occassional silt/sand bands. *(continued)*			
6.60-6.70	ES											
6.70-7.15	U											
7.15-7.35	B		0.0					(5.40)				
7.35	SPT	2,3,3 5,7,9 N=24(S)										
7.75-8.25	B										TILL	
8.60-9.05	U											
9.05-9.25	B		0.0									
9.30	SPT	3,4,5 7,9,11 N=32(S)										
9.40-9.90	B											
							30.22	9.90				
9.90-11.50	B		0.0						Stiff brown slightly sandy very gravelly CLAY. Gravel is subrounded to rounded, medium and of various lithologies. (GLACIAL TILL).			
9.97	SPT	10,15,27 N=27/ 0.06(S)						(1.85)			TILL	
							28.37	11.75				
									Borehole continued as a Cored Drillhole			

DRAFT

Boring Progress						Water Strikes					
Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt	Date	Time	Strike	Minutes	Standing	Casing

Chiselling				Water Added		General Remarks
From	To	Hours	Tool	From	To	

Scale 1:37.5

Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.

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ROTARY DRILLHOLE LOG

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Salford Quays, M50 3SP
Telephone: +44 (0)161 886 2400

Hole No. **BH1**

Project: Project RED

Sheet: 1 of 2

Job No: 70048625

Client: ENGIE Buildings Limited

Date: 20-08-18, 24-08-18

Contractor / Driller	Method/Plant Used	Logged By	Co-Ordinates (NGR)	Ground Level (m AOD)
Geotron UK Ltd	Comacchio 350	EM/RH	E 385106.388 N 396327.829	40.118

RUN DETAILS					STRATA								Install / Backfill
Depth	TCR	SCR	RQD	(SPT 'N') Fracture Spacing	Rock Test Result (MPa) Water Depth	Elev. (mAOD)	Depth (Thick-ness)	Discontinuities	Description Detail	Description Main	Legend	Geology	Dia. 50 mm
11.75						28.37	11.75			Brown clayey rounded fine to medium GRAVEL of various lithologies. (GLACIAL TILL).		TILL	
						28.12	12.00						

DRAFT

Boring Progress

Date	Time	Depth	Casing Dpt	Core Dia. (mm)	Water Strike

Chiselling

From	To	Hours	Tool

Water Added

From	To

Rotary Flush

From	To	Type	Return	Depth Casing	Casing Dia

General Remarks

Scale 1:37.5

Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.

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Salford Quays, M50 3SP
Telephone: +44 (0)161 886 2400

ROTARY DRILLHOLE LOG

Hole No. **BH1**

Project: Project RED

Sheet: 2 of 2

Job No: 70048625

Client: ENGIE Buildings Limited

Date: 20-08-18 24-08-18

Contractor / Driller	Method/Plant Used	Logged By	Co-Ordinates (NGR)	Ground Level (m AOD)
Geotron UK Ltd	Comacchio 350	EM/RH	E 385106.388 N 396327.829	40.118

RUN DETAILS					STRATA								Install / Backfill
Depth	TCR	SCR	RQD	(SPT 'N') Fracture Spacing	Rock Test Result (MPa) Water Depth	Elev. (mAOD)	Depth (Thick-ness)	Discontinuities	Detail	Description Main	Legend	Geology	Dia. 50 mm
	100	76	69							Very weak thinly bedded reddish brown slightly micaceous clayey MUDSTONE with occassional very thin beds of less clayey, stronger mudstone. Partially weathered at top of unit becoming stronger with depth. (MANCHESTER MARL) Joints: horizontal, stepped, rough, clean at 12.15m, 12.20m, and 12.55m bgl Bedding fractures: horizontal to subhorizontal (<10°), planar/undular, smooth, clean at 12.95m, 13.40m , 13.54m, and 14.17m bgl			
13.00							(1.97)	13.00 - 13.11 No recovery 13.11 - 14.20 Non-intact				MM	
	91	83	62			26.15	13.97						
						25.95	14.17			Weak greenish grey mottled reddish brown BRECCIA of medium and coarse angular gravel comprising mudstone, calcite, and quartz. (MANCHESTER MARL)		MM	
14.25								14.25 - 14.40 No recovery 14.40 - 14.52 Mudstone recovered as firm to stiff clay at the top of the core run		Very weak very thinly bedded reddish brown clayey MUDSTONE with very thin to thin (up to 70mm) beds of greenish grey mudstone. (MANCHESTER MARL) Bedding fractures: subhorizontal (<5°), planar, smooth, clean 14.55m, 14.65m, 14.68m, 14.73m, 14.85m bgl.			
	90	90	66				(1.63)					MM	
15.80						24.32	15.80						
										Borehole terminated at 15.8m bgl as target depth reached.		END	

DRAFT

Boring Progress						Rotary Flush					
Date	Time	Depth	Casing Dpt	Core Dia. (mm)	Water Strike	From	To	Type	Return	Depth Casing	Casing Dia

Chiselling				Water Added		General Remarks
From	To	Hours	Tool	From	To	

Scale 1:37.5

Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.

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BOREHOLE LOG

Hole No. **BH2**

Project: Project RED

Sheet: 1 of 4

Job No	Client	Date
70048625	ENGIE Buildings Limited	28-08-18 31-08-18

Contractor / Driller	Method/Plant Used	Logged By	Co-Ordinates (NGR)	Ground Level (m AOD)
Geotron UK Ltd	Comacchio 350	EM/RH	E 385115.191 N 396305.582	39.947

SAMPLES & TESTS							STRATA					
Depth	Type	Test Result	PID (ppmV)	HSV (kN/m2)	P.Pen (kN/m2)	Water	Elev. (mAOD)	Depth (Thick-ness)	Description	Legend	Geology	Install / Backfill
							39.86	0.09	ASPHALT		TARMAC	Dia. 50 mm
							39.70	0.25	CONCRETE		CONC	
			0.0					(0.35)	Light brown sandy GRAVEL. Gravel is angular, fine to coarse and of limestone (SUBBASE) (MADE GROUND).		GMG	
							39.35	0.60				
0.70-0.80	ES		0.0						Stiff brown locally mottled grey silty gravelly CLAY. Gravel is subangular to rounded, fine to medium and of various lithologies. (GLACIAL TILL)			
2.00-2.45	U											
2.45-2.70	B		0.0									
2.50-2.70	ES											
2.70	SPT	2,3,4 7,7,8 N=26(S)										
3.15-3.30	B											
3.30-3.75	U										TILL	
3.75-4.00	B											
4.00	SPT	2,3,4 5,7,8 N=24(S)										
4.45-4.90	U											
4.90-5.10	B		0.0									
5.10	SPT	1,2,3 4,6,6 N=19(S)						(9.80)				

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Boring Progress					
Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt

Water Strikes					
Date	Time	Strike	Minutes	Standing	Casing

Chiselling				Water Added	
From	To	Hours	Tool	From	To

General Remarks

Scale 1:37.5

Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.

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WSP The Victoria, 150-182 The Quays Salford Quays, M50 3SP Telephone: +44 (0)161 886 2400	**BOREHOLE LOG**	Hole No. **BH2**
	Project Project RED	Sheet 2 of 4
Job No 70048625	Client ENGIE Buildings Limited	Date 28-08-18 31-08-18

Contractor / Driller	Method/Plant Used	Logged By	Co-Ordinates (NGR)	Ground Level (m AOD)
Geotron UK Ltd	Comacchio 350	EM/RH	E 385115.191 N 396305.582	39.947

SAMPLES & TESTS							STRATA					Install / Backfill
Depth	Type	Test Result	PID (ppmV)	HSV (kN/m2)	P.Pen (kN/m2)	Water	Elev. (mAOD)	Depth (Thick-ness)	Description	Legend	Geology	Dia. 50 mm
6.35-6.80	U								Stiff brown locally mottled grey silty gravelly CLAY. Gravel is subangular to rounded, fine to medium and of various lithologies. (GLACIAL TILL) *(continued)*			
6.80-7.00	B											
7.00	SPT	1,3,3 5,5,7 N=20(S)										
											TILL	
8.30	SPT	2,3,5 6,8,10 N=29(S)										
9.10-10.00	B											
10.00	SPT	9,13,20 30 N=50/ 0.135(S)										
10.00-11.50	B						29.55	10.40				
								(0.80)	Very dense brown slightly sandy fine to medium GRAVEL. Gravel is angular to rounded and of various lithologies. (GLACIAL TILL).		TILL	
							28.75	11.20				
								(0.75)	Stiff brown silty gravelly CLAY. Gravel is rounded, fine to medium and of various lithologies. (GLACIAL TILL)		TILL	
							28.00	11.95				

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Boring Progress						Water Strikes					
Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt	Date	Time	Strike	Minutes	Standing	Casing

Chiselling				Water Added		General Remarks
From	To	Hours	Tool	From	To	

Scale 1:37.5	Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.

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WSP The Victoria, 150-182 The Quays Salford Quays, M50 3SP Telephone: +44 (0)161 886 2400	**BOREHOLE LOG**	Hole No. **BH2**
	Project Project RED	Sheet 3 of 4
Job No 70048625	Client ENGIE Buildings Limited	Date 28-08-18 31-08-18

Contractor / Driller	Method/Plant Used	Logged By	Co-Ordinates (NGR)	Ground Level (m AOD)
Geotron UK Ltd	Comacchio 350	EM/RH	E 385115.191 N 396305.582	39.947

SAMPLES & TESTS							STRATA					Install / Backfill
Depth	Type	Test Result	PID (ppmV)	HSV (kN/m2)	P.Pen (kN/m2)	Water	Elev. (mAOD)	Depth (Thick-ness)	Description	Legend	Geology	Dia. 50 mm
									Very weak reddish brown slightly micaceous clayey MUDSTONE. (MANCHESTER MARL) *(continued)*		MM	
								(0.70)			MM	
							27.30	12.65				
									Borehole terminated at 12.65m bgl as target depth reached.		END	

DRAFT

Boring Progress						Water Strikes					
Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt	Date	Time	Strike	Minutes	Standing	Casing

Chiselling				Water Added		General Remarks
From	To	Hours	Tool	From	To	

Scale 1:37.5	Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.

17 WSP BH LOG PROJECT RED GINT VERSION 2.GPJ WSPETEMPLATE7.00.GDT 15/10/18

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BOREHOLE LOG

Hole No. **BH3**

Project: Project RED

Sheet: 1 of 2

Job No: 70048625

Client: ENGIE Buildings Limited

Date: 24-08-18
24-08-18

Contractor / Driller	Method/Plant Used	Logged By	Co-Ordinates (NGR)	Ground Level (m AOD)
Geotron UK Ltd	Hand Held Window Sampler	EM	E 385126.951 N 396277.479	40.020

SAMPLES & TESTS							STRATA					
Depth	Type	Test Result	PID (ppmV)	HSV (kN/m2)	P.Pen (kN/m2)	Water	Elev. (mAOD)	Depth (Thick-ness)	Description	Legend	Geology	Install / Backfill Dia. 50 mm
							39.97	0.05	ASPHALT		TARMAC	
0.20-0.30	ES		0.0					(0.25)	Light brown clayey sandy GRAVEL of limestone. (SUBBASE) (MADE GROUND).		GMG	
			0.0				39.72	0.30	Light brown sandy gravelly CLAY. Gravel is angular to subangular, fine to coarse and of limestone with fine to medium gravel sized fragments of brick, concrete and glass. (MADE GROUND).			
0.65-0.75	ES		0.0									
			0.0									
			0.0					(1.70)			CMG	
1.40-1.50	ES		0.0									
			0.0				38.02	2.00	Firm to stiff brown gravelly CLAY. Gravel is angular, fine to medium and of coal and various lithologies.			
2.40-2.50	ES		0.0					(0.50)			TILL	
							37.52	2.50	Borehole terminated at 2.50m bgl as target depth reached.		END	

DRAFT

Boring Progress						Water Strikes					
Date	Time	Depth	Casing Dpt	Dia. (mm)	Water Dpt	Date	Time	Strike	Minutes	Standing	Casing

Chiselling				Water Added		General Remarks
From	To	Hours	Tool	From	To	

Scale 1:25

Notes: All dimensions in metres. Logs should be read in accordance with the provided Key. Descriptions are based on visual and manual identification.

17 WSP BH LOG PROJECT RED GINT VERSION 2.GPJ WSPETEMPLATE7.00.GDT 15/10/18

FIELD LOG

SUB SURFACE
SITE INVESTIGATION AND SPECIALIST GEOTECHNICAL CONSULTANTS
3 Peel Street, Preston, PR2 2QS. Tel. (01772) 561135 Fax (01772) 204907

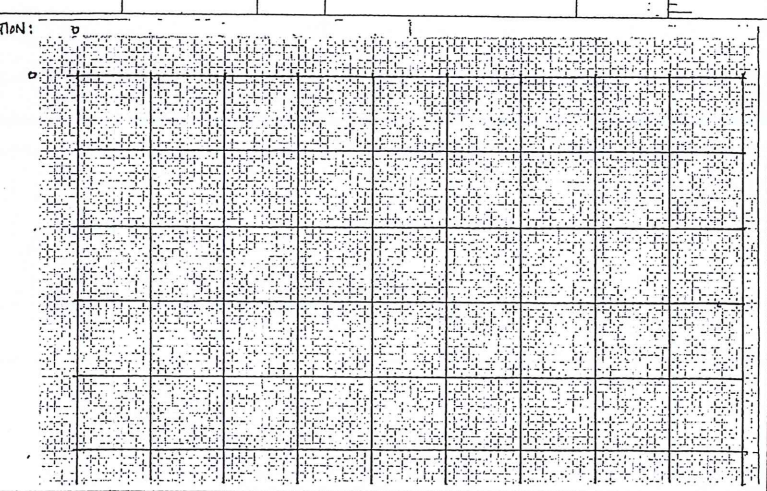
Site: Project Red, Manchester Royal Infirmary, Oxford Road, Manchester.

Trialpit Number: HD 1

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
HAND DUG	0.60 m × 0.40 m		Walker Sime Limited	6549

Location	Dates	Engineer	Sheet
AS PLAN	14/06/2018		1/6

Depth m	Samples / Tests	Water Depth m	Field Records	Level (mOD)	Depth m (Thickness)	Description	Legend	Water
0.15-0.25	B	558			0.00	MG- brick paving layer.		
0.30-0.50	B	559			0.06			
						MG- orangish brown fine sand.		
					0.11			
						MG- light grey sandy fine to coarse gravel sized fragments of stone.		
					0.28			
						MG- brown sandy fine to coarse gravel sized fragments of stone and brick.		
					0.55			
						COMPLETE AT 0.55m		



SECTION: 1:

Remarks

No groundwater encountered

Pit sides collapsing from [0.06] m.

See key sheet for symbols and abbreviations

Scale (approx)	Logged By	Figure No.
1:25	MSB/	

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FIELD LOG

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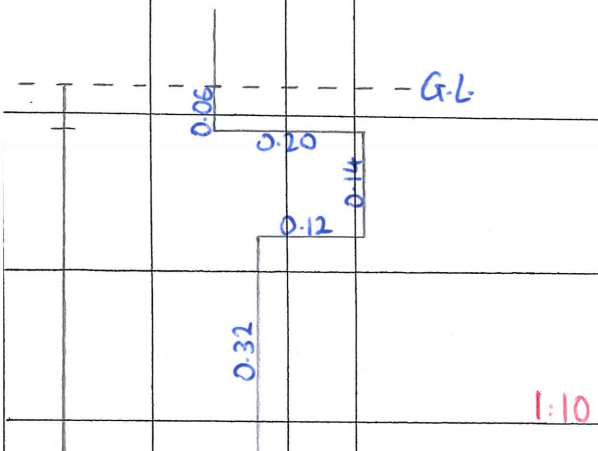
3 Peel Street, Preston, PR2 2QS. Tel. (01772) 561135 Fax (01772) 204907

Site: Project Red, Manchester Royal Infirmary, Oxford Road, Manchester.

Trialpit Number: HD 2

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
HAND DUG	0.40m x 0.40 m		Walker Sime Limited	6549
	Location	**Dates**	**Engineer**	**Sheet**
	AS PLAN	14/06/2018		2/6

Depth m	Samples / Tests	Water Depth m	Field Records	Level (mOD)	Depth m (Thickness)	Description	Legend	Water
0.12-0.18	B	560			0.00	MG-brick paving layer.		
0.30-0.50	B	561			0.06	MG-orangish brown fine sand.		
					0.12	MG-light grey sandy fine to coarse gravel sized fragments of stone.		
					0.18	MG-brown very gravelly medium to coarse sand. Gravel sized fragments are fine to coarse stone, concrete and brick.		
					0.60	COMPLETE AT 0.60m		



SECTION:

Remarks

No groundwater encountered

Pitsides collapsing from [0.06] m.

See key sheet for symbols and abbreviations

Scale (approx)	Logged By	Figure No.
1:25	MSB/	

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FIELD LOG

SUB SURFACE

SITE INVESTIGATION AND SPECIALIST GEOTECHNICAL CONSULTANTS
3 Peel Street, Preston, PR2 2QS. Tel. (01772) 561135 Fax (01772) 204907

Site: Project Red, Manchester Royal Infirmary, Oxford Road, Manchester.

Trialpit Number: HD 3

Excavation Method: HAND DUG

Dimensions: 0.50m × 0.40 m

Ground Level (mOD):

Client: Walker Sime Limited

Job Number: 6549

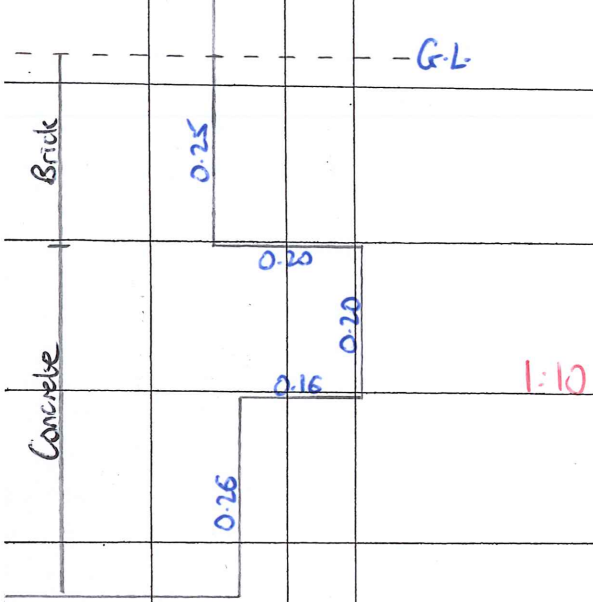
Location: AS PLAN

Dates: 14/06/2018

Engineer:

Sheet: 3/6

Depth m	Samples / Tests	Water Depth m	Field Records	Level (mOD)	Depth m (Thickness)	Description	Legend	Water
0.20-0.40	B	562			0.00	MG - bituminous macadam layer.		
0.60-0.75	B	563			0.09	MG - light greyish brown sandy fine to coarse gravel sized fragments of stone.		
					0.55	MG - orangish brown very sandy fine to coarse gravel sized and cobble sized fragments of stone and brick.		
					0.75	COMPLETE AT 0.75m		



SECTION: 1:

Remarks

No groundwater encountered

Pitsides collapsing from 0.09 m.

See key sheet for symbols and abbreviations

Scale (approx)	Logged By	Figure No.
1:25	MSB/	

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FIELD LOG

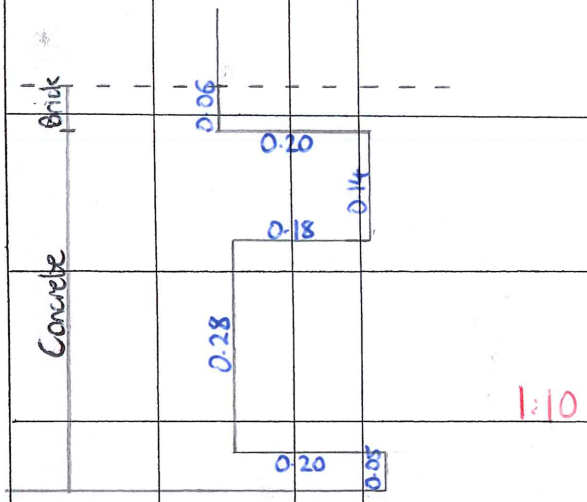
SUB SURFACE
SITE INVESTIGATION AND SPECIALIST GEOTECHNICAL CONSULTANTS
3 Peel Street, Preston, PR2 2QS. Tel. (01772) 561135 Fax (01772) 204907

Site: Project Red, Manchester Royal Infirmary, Oxford Road, Manchester.

Trialpit Number: HD4

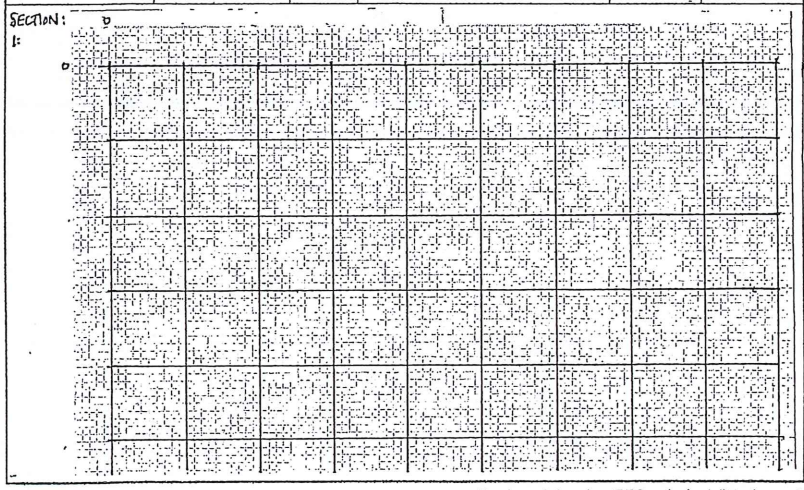
Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
HAND DUG	0.40m × 0.40 m		Walker Sime Limited	6549
	Location	**Dates**	**Engineer**	**Sheet**
	AS PLAN	14/06/2018		4/6

Depth m	Samples / Tests	Water Depth m	Field Records	Level (mOD)	Depth m (Thickness)	Description	Legend	Water
0.12-0.23	B	564			0.00	MG- brick paving layer		
0.40-0.60	B	565			0.06			
						MG- orangish brown fine sand.		
					0.12			
						MG- brown and grey sandy fine to coarse gravel sized fragments of stone.		
					0.23			
						MC- brown very gravelly silty fine to coarse sand with occasional pockets of clay, and medium cobble sized fragments of stone and brick. Gravel sized fragments are fine to coarse stone, brick and concrete.		
					0.65			



COMPLETE AT 0.65m

SECTION: 1:



Remarks

No groundwater encountered

Pit sides collapsing from [0.06] m.

See key sheet for symbols and abbreviations

Scale (approx)	Logged By	Figure No.
1:25	MSB/	

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HELD LOG

SUB SURFACE
SITE INVESTIGATION AND SPECIALIST GEOTECHNICAL CONSULTANTS
3 Peel Street, Preston, PR2 2QS. Tel. (01772) 561135 Fax (01772) 204907

Site: Project Red, Manchester Royal Infirmary, Oxford Road, Manchester.

Trialpit Number: HD 5

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
HAND DUG	0.70m x 0.40m		Walker Sime Limited	6549
	Location	**Dates**	**Engineer**	**Sheet**
	AS PLAN	15/06/2018		5/6

Depth m	Samples / Tests	Water Depth m	Field Records	Level (mOD)	Depth m (Thickness)	Description	Legend	Water
0.10-0.30	B	566			0.00	MG- bituminous macadam layer		
0.40-0.60	B	567			0.06			
0.80-1.00	B	568				MG- dark brown slightly ashy sandy fine to coarse gravel sized fragments of stone, brick and bituminous macadam.		
					0.30			
			GL			MG- soft dark brown and grey gravelly sandy silty clay with low cobble sized fragments of stone. Gravel sized fragments are fine to coarse stone and brick.		
					0.65			
Brick						MG- grey sandy fine to coarse gravel sized and cobble sized fragments of stone and brick.		
					1.20			
Breeze blocks	0.63							
		0.33	0.07					
			0.02					
Concrete			Unknown depth.			COMPLETE AT 1.20 m		

SECTION: 1:

Remarks

No groundwater encountered

Unable to locate underside of foundation. Greater than 1.20m in depth.

Pitsides collapsing from [0.06 to 0.30] m.

See key sheet for symbols and abbreviations

Scale (approx)	Logged By	Figure No.
1:25	MSB/	

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FIELD LOG

SUB SURFACE

SITE INVESTIGATION AND SPECIALIST GEOTECHNICAL CONSULTANTS
3 Peel Street, Preston, PR2 2QS. Tel. (01772) 561135 Fax (01772) 204907

Site: Project Red, Manchester Royal Infirmary, Oxford Road, Manchester.			Trialpit Number: HD6
Excavation Method: HAND DUG	Dimensions: 0.60 m × 0.40 m	Ground Level (mOD):	Client: Walker Sime Limited
			Job Number: 6549
	Location: AS PLAN	Dates: 15/06/2018	Engineer:
			Sheet: 6/6

Depth m	Samples / Tests	Water Depth m	Field Records	Level (mOD)	Depth m (Thickness)	Description	Legend	Water
0.12-0.32	B	S69			0.00	MG- brick paving layer		
0.40-0.60	B	S70						
0.70-0.90	B	S71			0.08			
1.00-1.20	B	S72				MG- orangish brown fine sand.		
					0.12			
Brick						MG- brown very sandy fine to coarse gravel sized fragments of stone.		
					0.32			
	0.75					MG- brown sandy fine to coarse gravel sized and cobble sized fragments of stone and brick with occasional pockets of clay.		
Breeze blocks					0.65			
						MG- soft brown, grey, orangish brown and dark grey mottled gravelly slightly sandy silty clay. Gravel sized fragments are fine to coarse stone, brick and concrete.		
					0.95			
	0.20					Stiff brown and grey mottled slightly gravelly slightly sandy silty CLAY. Gravel is subangular to subrounded fine to coarse siltstone and quartz.		
	0.16				1.20			
Concrete		0.04						
	0.25		1:10					
						COMPLETE AT 1.20 m		

SECTION: 1:

Remarks

No groundwater encountered

Pitsides collapsing from [0.08 to 0.32] m.

See key sheet for symbols and abbreviations

Scale (approx)	Logged By	Figure No.
1:25	MSB/	

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Appendix D

LABORATORY TESTING

CERTIFICATES

Appendix D.1

CHEMICAL TESTING

Unit 7-8 Hawarden Business Park
Manor Road (off Manor Lane)
Hawarden
Deeside
CH5 3US
Tel: (01244) 528700
Fax: (01244) 528701
email: hawardencustomerservices@alsglobal.com
Website: www.alsenvironmental.co.uk

WSP PB MLN
The Victoria
150-182 The Quays
Salford
Manchester
Lancashire
M50 3SP

Attention: Emily Morgan

CERTIFICATE OF ANALYSIS

Date:	13 September 2018
Customer:	H_WSP_MAN
Sample Delivery Group (SDG):	180903-58
Your Reference:	70048625 - Project RED
Location:	MRI - Project RED
Report No:	472235

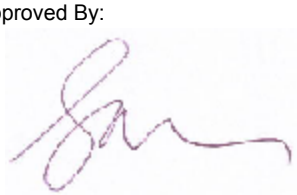
This report has been revised and directly supersedes 472008 in its entirety.

We received 11 samples on Monday September 03, 2018 and 8 of these samples were scheduled for analysis which was completed on Tuesday September 11, 2018. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

Chemical testing (unless subcontracted) performed at ALS Environmental Hawarden (Method codes TM) or ALS Environmental Aberdeen (Method codes S).

Approved By:



Sonia McWhan

Operations Manager

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CERTIFICATE OF ANALYSIS

SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
18251403	BH1	ES	0.20 - 0.30	22/08/2018
18251413	BH1	ES	0.80 - 0.90	22/08/2018
18251420	BH1	ES	2.20 - 2.30	22/08/2018
18251426	BH1	ES	3.40 - 3.50	22/08/2018
18251435	BH1	ES	6.60 - 6.70	23/08/2018
18246425	BH2	ES	0.70 - 0.80	29/08/2018
18246430	BH2	ES	2.50 - 2.70	29/08/2018
18251441	BH3	ES	0.20 - 0.30	24/08/2018
18251447	BH3	ES	0.65 - 0.75	24/08/2018
18251454	BH3	ES	1.40 - 1.50	24/08/2018
18251461	BH3	ES	2.40 - 2.50	24/08/2018

Maximum Sample/Coolbox Temperature (°C) : **14.2**

ISO5667-3 Water quality - Sampling - Part3 -
During Transportation samples shall be stored in a cooling device capable of maintaining a temperature of (5±3)°C.

ALS have data which show that a cool box with 4 frozen icepacks is capable of maintaining pre-chilled samples at a temperature of (5±3)°C for a period of up to 24hrs.

Only received samples which have had analysis scheduled will be shown on the following pages.

Validated

CERTIFICATE OF ANALYSIS

SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Results Legend

X **Test**

N **No Determination Possible**

Sample Types -
S - Soil/Solid
UNS - Unspecified Solid
GW - Ground Water
SW - Surface Water
LE - Land Leachate
PL - Prepared Leachate
PR - Process Water
SA - Saline Water
TE - Trade Effluent
TS - Treated Sewage
US - Untreated Sewage
RE - Recreational Water
DW - Drinking Water Non-regulatory
UNL - Unspecified Liquid
SL - Sludge
G - Gas
OTH - Other

			Lab Sample No(s)	Customer Sample Reference	AGS Reference	Depth (m)	Container	Sample Type
			18251413	BH1	ES	0.80 - 0.90	1kg TUB	S
							250g Amber Jar (ALE210)	S
							60g VOC (ALE215)	S
			18251420	BH1	ES	2.20 - 2.30	250g Amber Jar (ALE210)	S
							60g VOC (ALE215)	S
			18251426	BH1	ES	3.40 - 3.50	250g Amber Jar (ALE210)	S
			18246425	BH2	ES	0.70 - 0.80	250g Amber Jar (ALE210)	S
							60g VOC (ALE215)	S
			18251441	BH3	ES	0.20 - 0.30	1kg TUB	S
			18251447	BH3	ES	0.65 - 0.75	1kg TUB	S
							250g Amber Jar (ALE210)	S
							60g VOC (ALE215)	S
			18251454	BH3	ES	1.40 - 1.50	1kg TUB	S
							250g Amber Jar (ALE210)	S
			18251461	BH3	ES	2.40 - 2.50	250g Amber Jar (ALE210)	S
Anions by Kone (soil)	All	NDPs: 0 Tests: 7						
				X		X		
				X		X	X	
							X	X
Asbestos ID in Solid Samples	All	NDPs: 0 Tests: 4						
			X					
							X	
EPH CWG (Aliphatic) GC (S)	All	NDPs: 0 Tests: 4						
				X		X		
				X		X		
							X	
EPH CWG (Aromatic) GC (S)	All	NDPs: 0 Tests: 4						
				X		X		
				X		X		
							X	
GRO by GC-FID (S)	All	NDPs: 0 Tests: 4						
					X		X	
					X		X	
							X	
Metals in solid samples by OES	All	NDPs: 0 Tests: 4						
				X		X		
				X		X		
							X	
PAH by GCMS	All	NDPs: 0 Tests: 4						
				X		X		
				X		X		
							X	
pH	All	NDPs: 0 Tests: 7						
				X		X		
				X		X	X	
							X	X
Sample description	All	NDPs: 0 Tests: 7						
				X		X		
				X		X	X	
							X	X
TPH CWG GC (S)	All	NDPs: 0 Tests: 4						
				X		X		
				X		X		
							X	
VOC MS (S)	All	NDPs: 0 Tests: 4						
					X		X	
					X		X	
							X	

CERTIFICATE OF ANALYSIS

SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Sample Descriptions

Grain Sizes

very fine	<0.063mm	**fine**	0.063mm - 0.1mm	**medium**	0.1mm - 2mm	**coarse**	2mm - 10mm	**very coarse**	>10mm

Lab Sample No(s)	Customer Sample Ref.	Depth (m)	Colour	Description	Inclusions	Inclusions 2
18251413	BH1	0.80 - 0.90	Grey	Sand	Stones	None
18251420	BH1	2.20 - 2.30	Dark Brown	Clay	None	None
18251426	BH1	3.40 - 3.50	Dark Brown	Clay Loam	Stones	Vegetation
18246425	BH2	0.70 - 0.80	Dark Brown	Silty Clay Loam	Vegetation	None
18251447	BH3	0.65 - 0.75	Dark Brown	Loamy Sand	Stones	None
18251454	BH3	1.40 - 1.50	Dark Brown	Clay Loam	Stones	Vegetation
18251461	BH3	2.40 - 2.50	Dark Brown	Clay Loam	None	None

These descriptions are only intended to act as a cross check if sample identities are questioned, and to provide a log of sample matrices with respect to MCERTS validation. They are not intended as full geological descriptions.

We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally ocurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample.

Other coarse granular materials such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

CERTIFICATE OF ANALYSIS

SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH1	BH1	BH2	BH3	BH3
			Depth (m)	0.80 - 0.90	2.20 - 2.30	3.40 - 3.50	0.70 - 0.80	0.65 - 0.75	1.40 - 1.50
			Sample Type	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)
			Date Sampled	22/08/2018	22/08/2018	22/08/2018	29/08/2018	24/08/2018	24/08/2018
			Sampled Time	.	.	.	.	.	.
			Date Received	03/09/2018	03/09/2018	03/09/2018	03/09/2018	03/09/2018	03/09/2018
			SDG Ref	180903-58	180903-58	180903-58	180903-58	180903-58	180903-58
			Lab Sample No.(s)	18251413	18251420	18251426	18246425	18251447	18251454
			AGS Reference	ES	ES	ES	ES	ES	ES
Moisture Content Ratio (% of as received sample)	%	PM024		2.3	17	11	19	6.3	16
pH	1 pH Units	TM133		9.71 M	8.68 M	8.72 M	8.79 M	9.05 M	8.86 M
Arsenic	<0.6 mg/kg	TM181		<0.6 M	5.15 M		8.15 M	1.59 M	
Cadmium	<0.02 mg/kg	TM181		0.302 M	0.0412 M		0.589 M	0.916 M	
Chromium	<0.9 mg/kg	TM181		4.22 M	28.8 M		27.5 M	7.61 M	
Copper	<1.4 mg/kg	TM181		2.67 M	22.9 M		22.9 M	6.75 M	
Lead	<0.7 mg/kg	TM181		3.53 M	10.2 M		14.3 M	21.9 M	
Mercury	<0.14 mg/kg	TM181		<0.14 M	<0.14 M		<0.14 M	<0.14 M	
Nickel	<0.2 mg/kg	TM181		4.64 M	36.1 M		37.2 M	9.66 M	
Selenium	<1 mg/kg	TM181		<1 #	<1 #		<1 #	<1 #	
Zinc	<1.9 mg/kg	TM181		27.1 M	85.8 M		95.9 M	47.8 M	
Water Soluble Sulphate as SO4 2:1 Extract	<0.004 g/l	TM243		0.0102 M	0.066 M	0.0389 M	0.153 M	0.0143 M	0.0182 M

CERTIFICATE OF ANALYSIS

SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Customer Sample Ref.	BH3
Depth (m)	2.40 - 2.50
Sample Type	Soil/Solid (S)
Date Sampled	24/08/2018
Sampled Time	.
Date Received	03/09/2018
SDG Ref	180903-58
Lab Sample No.(s)	18251461
AGS Reference	ES

Component	LOD/Units	Method	
Moisture Content Ratio (% of as received sample)	%	PM024	17
pH	1 pH Units	TM133	8.67 M
Water Soluble Sulphate as SO4 2:1 Extract	<0.004 g/l	TM243	0.0389 M

CERTIFICATE OF ANALYSIS

SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

PAH by GCMS

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH1	BH2	BH3		
			Depth (m)	0.80 - 0.90	2.20 - 2.30	0.70 - 0.80	0.65 - 0.75		
			Sample Type	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)		
			Date Sampled	22/08/2018	22/08/2018	29/08/2018	24/08/2018		
			Sampled Time	.	.	.	.		
			Date Received	03/09/2018	03/09/2018	03/09/2018	03/09/2018		
			SDG Ref	180903-58	180903-58	180903-58	180903-58		
			Lab Sample No.(s)	18251413	18251420	18246425	18251447		
			AGS Reference	ES	ES	ES	ES		
Naphthalene-d8 % recovery**	%	TM218		89	85.1	83.5	88.2		
Acenaphthene-d10 % recovery**	%	TM218		86.8	81.1	82.4	87		
Phenanthrene-d10 % recovery**	%	TM218		88.3	81.9	79.5	87.6		
Chrysene-d12 % recovery**	%	TM218		77	71.3	85.1	75.3		
Perylene-d12 % recovery**	%	TM218		79.7	71.1	85.2	78.9		
Naphthalene	<0.009 mg/kg	TM218		<0.009 @ M	<0.009 @ M	<0.009 M	<0.009 M		
Acenaphthylene	<0.012 mg/kg	TM218		<0.012 @ M	<0.012 @ M	<0.012 M	<0.012 M		
Acenaphthene	<0.008 mg/kg	TM218		<0.008 @ M	<0.008 @ M	<0.008 M	<0.008 M		
Fluorene	<0.01 mg/kg	TM218		<0.01 @ M	<0.01 @ M	<0.01 M	<0.01 M		
Phenanthrene	<0.015 mg/kg	TM218		0.0407 @ M	<0.015 @ M	<0.015 M	<0.015 M		
Anthracene	<0.016 mg/kg	TM218		<0.016 @ M	<0.016 @ M	<0.016 M	<0.016 M		
Fluoranthene	<0.017 mg/kg	TM218		0.08 @ M	<0.017 @ M	<0.017 M	<0.017 M		
Pyrene	<0.015 mg/kg	TM218		0.0763 @ M	<0.015 @ M	<0.015 M	0.0176 M		
Benz(a)anthracene	<0.014 mg/kg	TM218		0.0388 @ M	<0.014 @ M	<0.014 M	<0.014 M		
Chrysene	<0.01 mg/kg	TM218		0.0304 @ M	<0.01 @ M	<0.01 M	<0.01 M		
Benzo(b)fluoranthene	<0.015 mg/kg	TM218		0.0439 @ M	<0.015 @ M	<0.015 M	<0.015 M		
Benzo(k)fluoranthene	<0.014 mg/kg	TM218		0.0157 @ M	<0.014 @ M	<0.014 M	<0.014 M		
Benzo(a)pyrene	<0.015 mg/kg	TM218		0.0362 @ M	<0.015 @ M	<0.015 M	<0.015 M		
Indeno(1,2,3-cd)pyrene	<0.018 mg/kg	TM218		0.0289 @ M	<0.018 @ M	<0.018 M	<0.018 M		
Dibenzo(a,h)anthracene	<0.023 mg/kg	TM218		<0.023 @ M	<0.023 @ M	<0.023 M	<0.023 M		
Benzo(g,h,i)perylene	<0.024 mg/kg	TM218		0.0333 @ M	<0.024 @ M	<0.024 M	<0.024 M		
PAH, Total Detected USEPA 16	<0.118 mg/kg	TM218		0.424	<0.118	<0.118	<0.118		

CERTIFICATE OF ANALYSIS

SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

TPH CWG (S)

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH1	BH2	BH3		
			Depth (m)	0.80 - 0.90	2.20 - 2.30	0.70 - 0.80	0.65 - 0.75		
			Sample Type	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)		
			Date Sampled	22/08/2018	22/08/2018	29/08/2018	24/08/2018		
			Sampled Time	.	.	.	.		
			Date Received	03/09/2018	03/09/2018	03/09/2018	03/09/2018		
			SDG Ref	180903-58	180903-58	180903-58	180903-58		
			Lab Sample No.(s)	18251413	18251420	18246425	18251447		
			AGS Reference	ES	ES	ES	ES		
GRO Surrogate % recovery**	%	TM089		107 @	73 @	88	99		
GRO TOT (Moisture Corrected)	<0.1 mg/kg	TM089		<0.1 @ M	<0.1 @ M	<0.1 M	<0.1 M		
Aliphatics >C5-C6	<0.01 mg/kg	TM089		<0.01 @	<0.01 @	<0.01	<0.01		
Aliphatics >C6-C8	<0.01 mg/kg	TM089		<0.01 @	<0.01 @	<0.01	<0.01		
Aliphatics >C8-C10	<0.01 mg/kg	TM089		<0.01 @	<0.01 @	<0.01	<0.01		
Aliphatics >C10-C12	<0.01 mg/kg	TM089		<0.01 @	<0.01 @	<0.01	<0.01		
Aliphatics >C12-C16	<0.1 mg/kg	TM173		<0.1	0.874	<0.1	<0.1		
Aliphatics >C16-C21	<0.1 mg/kg	TM173		0.891	2.44	1.57	<0.1		
Aliphatics >C21-C35	<0.1 mg/kg	TM173		16.4	4.49	3.62	5.43		
Aliphatics >C35-C44	<0.1 mg/kg	TM173		1.18	<0.1	<0.1	0.827		
Total Aliphatics >C12-C44	<0.1 mg/kg	TM173		18.5	7.8	5.2	6.26		
Aromatics >EC5-EC7	<0.01 mg/kg	TM089		<0.01 @	<0.01 @	<0.01	<0.01		
Aromatics >EC7-EC8	<0.01 mg/kg	TM089		<0.01 @	<0.01 @	<0.01	<0.01		
Aromatics >EC8-EC10	<0.01 mg/kg	TM089		<0.01 @	<0.01 @	<0.01	<0.01		
Aromatics >EC10-EC12	<0.01 mg/kg	TM089		<0.01 @	<0.01 @	<0.01	<0.01		
Aromatics >EC12-EC16	<0.1 mg/kg	TM173		<0.1	<0.1	<0.1	<0.1		
Aromatics >EC16-EC21	<0.1 mg/kg	TM173		<0.1	0.756	1.72	<0.1		
Aromatics >EC21-EC35	<0.1 mg/kg	TM173		3.11	5.39	6.45	3.74		
Aromatics >EC35-EC44	<0.1 mg/kg	TM173		<0.1	0.536	0.611	1.03		
Aromatics >EC40-EC44	<0.1 mg/kg	TM173		<0.1	<0.1	<0.1	<0.1		
Total Aromatics >EC12-EC44	<0.1 mg/kg	TM173		3.11	6.68	8.77	4.77		
Total Aliphatics & Aromatics >C5-C44	<0.1 mg/kg	TM173		21.6	14.5	14	11		
Aromatics >EC16-EC35	<0.1 mg/kg	TM173		3.11	6.14	8.16	3.74		

CERTIFICATE OF ANALYSIS

SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

VOC MS (S)

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH1	BH2	BH3		
			Depth (m)	0.80 - 0.90	2.20 - 2.30	0.70 - 0.80	0.65 - 0.75		
			Sample Type	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)		
			Date Sampled	22/08/2018	22/08/2018	29/08/2018	24/08/2018		
			Sampled Time	.	.	.	.		
			Date Received	03/09/2018	03/09/2018	03/09/2018	03/09/2018		
			SDG Ref	180903-58	180903-58	180903-58	180903-58		
			Lab Sample No.(s)	18251413	18251420	18246425	18251447		
			AGS Reference	ES	ES	ES	ES		
Methyl Tertiary Butyl Ether	<0.01 mg/kg	TM116		<0.1 @ M	<0.1 @ M	<0.1 M	<0.1 M		
Benzene	<0.009 mg/kg	TM116		<0.09 @ M	<0.09 @ M	<0.09 M	<0.09 M		
Toluene	<0.007 mg/kg	TM116		<0.07 @ M	<0.07 @ M	<0.07 M	<0.07 M		
Ethylbenzene	<0.004 mg/kg	TM116		<0.04 @ M	<0.04 @ M	<0.04 M	<0.04 M		
p/m-Xylene	<0.01 mg/kg	TM116		<0.1 @ #	<0.1 @ #	<0.1 #	<0.1 #		
o-Xylene	<0.01 mg/kg	TM116		<0.1 @ M	<0.1 @ M	<0.1 M	<0.1 M		
Tert-amyl methyl ether	<0.01 mg/kg	TM116		<0.1 @ #	<0.1 @ #	<0.1 #	<0.1 #		

CERTIFICATE OF ANALYSIS

SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Asbestos Identification - Soil

		Date of Analysis	Analysed By	Comments	Amosite (Brown) Asbestos	Chrysotile (White) Asbestos	Crocidolite (Blue) Asbestos	Fibrous Actinolite	Fibrous Anthophyllite	Fibrous Tremolite	Non-Asbestos Fibre
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Receieved SDG Original Sample Method Number	BH1 ES 0.80 - 0.90 SOLID 22/08/2018 00:00:00 04/09/2018 14:10:56 180903-58 18251413 TM048	06/09/2018	Barbara Urbanek-Walsh	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Receieved SDG Original Sample Method Number	BH3 ES 0.20 - 0.30 SOLID 24/08/2018 00:00:00 04/09/2018 14:01:23 180903-58 18251441 TM048	06/09/2018	Barbara Urbanek-Walsh	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Receieved SDG Original Sample Method Number	BH3 ES 0.65 - 0.75 SOLID 24/08/2018 00:00:00 04/09/2018 14:09:01 180903-58 18251447 TM048	06/09/2018	Barbara Urbanek-Walsh	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Receieved SDG Original Sample Method Number	BH3 ES 1.40 - 1.50 SOLID 24/08/2018 00:00:00 04/09/2018 14:10:42 180903-58 18251454 TM048	06/09/2018	Lucy Caroe	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected

CERTIFICATE OF ANALYSIS

SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Table of Results - Appendix

Method No	Reference	Description
PM001		Preparation of Samples for Metals Analysis
PM024	Modified BS 1377	Soil preparation including homogenisation, moisture screens of soils for Asbestos Containing Material
TM048	HSG 248, Asbestos: The analysts' guide for sampling, analysis and clearance procedures	Identification of Asbestos in Bulk Material
TM089	Modified: US EPA Methods 8020 & 602	Determination of Gasoline Range Hydrocarbons (GRO) by Headspace GC-FID (C4-C12)
TM116	Modified: US EPA Method 8260, 8120, 8020, 624, 610 & 602	Determination of Volatile Organic Compounds by Headspace / GC-MS
TM133	BS 1377: Part 3 1990;BS 6068-2.5	Determination of pH in Soil and Water using the GLpH pH Meter
TM173	Analysis of Petroleum Hydrocarbons in Environmental Media – Total Petroleum Hydrocarbon Criteria	Determination of Speciated Extractable Petroleum Hydrocarbons in Soils by GC-FID
TM181	US EPA Method 6010B	Determination of Routine Metals in Soil by iCap 6500 Duo ICP-OES
TM218	Shaker extraction - EPA method 3546.	The determination of PAH in soil samples by GC-MS
TM243		Mixed Anions In Soils By Kone

NA = not applicable.

Chemical testing (unless subcontracted) performed at ALS Environmental Hawarden (Method codes TM) or ALS Environmental Aberdeen (Method codes S).

CERTIFICATE OF ANALYSIS

SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Test Completion Dates

Lab Sample No(s)	18251413	18251420	18251426	18246425	18251441	18251447	18251454	18251461
Customer Sample Ref.	BH1	BH1	BH1	BH2	BH3	BH3	BH3	BH3
AGS Ref.	ES	ES	ES	ES	ES	ES	ES	ES
Depth	0.80 - 0.90	2.20 - 2.30	3.40 - 3.50	0.70 - 0.80	0.20 - 0.30	0.65 - 0.75	1.40 - 1.50	2.40 - 2.50
Type	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)
Anions by Kone (soil)	06-Sep-2018	11-Sep-2018	10-Sep-2018	11-Sep-2018		06-Sep-2018	07-Sep-2018	07-Sep-2018
Asbestos ID in Solid Samples	06-Sep-2018				06-Sep-2018	06-Sep-2018	06-Sep-2018	
EPH CWG (Aliphatic) GC (S)	10-Sep-2018	10-Sep-2018		07-Sep-2018		07-Sep-2018		
EPH CWG (Aromatic) GC (S)	10-Sep-2018	10-Sep-2018		07-Sep-2018		07-Sep-2018		
GRO by GC-FID (S)	09-Sep-2018	09-Sep-2018		09-Sep-2018		09-Sep-2018		
Metals in solid samples by OES	06-Sep-2018	11-Sep-2018		11-Sep-2018		06-Sep-2018		
PAH by GCMS	06-Sep-2018	07-Sep-2018		06-Sep-2018		06-Sep-2018		
pH	10-Sep-2018	10-Sep-2018	10-Sep-2018	10-Sep-2018		11-Sep-2018	10-Sep-2018	10-Sep-2018
Sample description	04-Sep-2018	04-Sep-2018	05-Sep-2018	04-Sep-2018		04-Sep-2018	05-Sep-2018	05-Sep-2018
TPH CWG GC (S)	10-Sep-2018	10-Sep-2018		09-Sep-2018		09-Sep-2018		
VOC MS (S)	08-Sep-2018	08-Sep-2018		08-Sep-2018		08-Sep-2018		

CERTIFICATE OF ANALYSIS

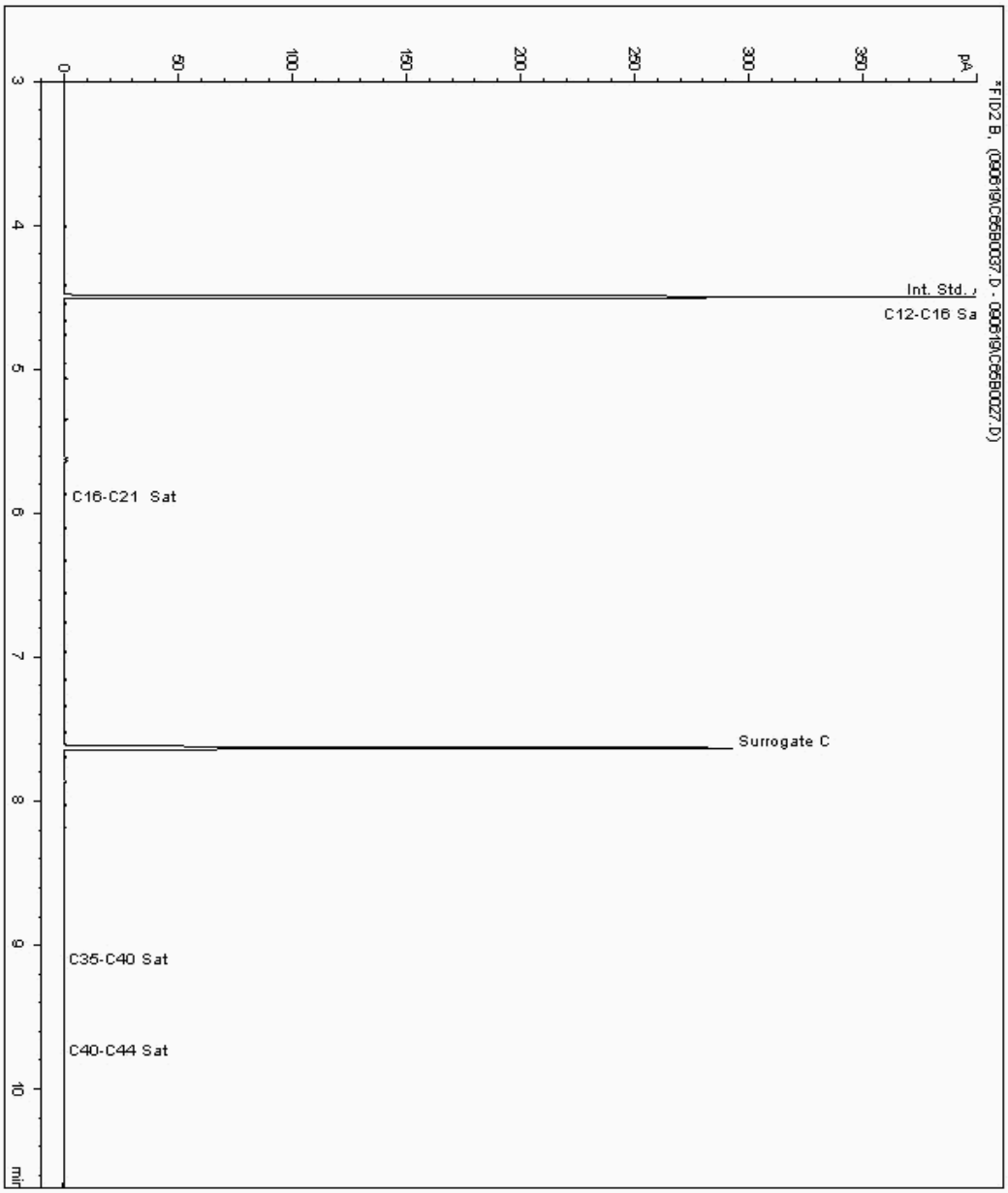
SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Chromatogram

Analysis: EPH CWG (Aliphatic) GC (S) **Sample No :** 18250335 **Depth :** 0.70 - 0.80
Sample ID : BH2

Speciated TPH - AROM (C12 - C40)

Sample Identity: 17142339-
Date Acquired : 07/09/2018 00:31:41 PM
Units : ppb
Dilution: BH2[0.70 - 0.80] ->



CERTIFICATE OF ANALYSIS

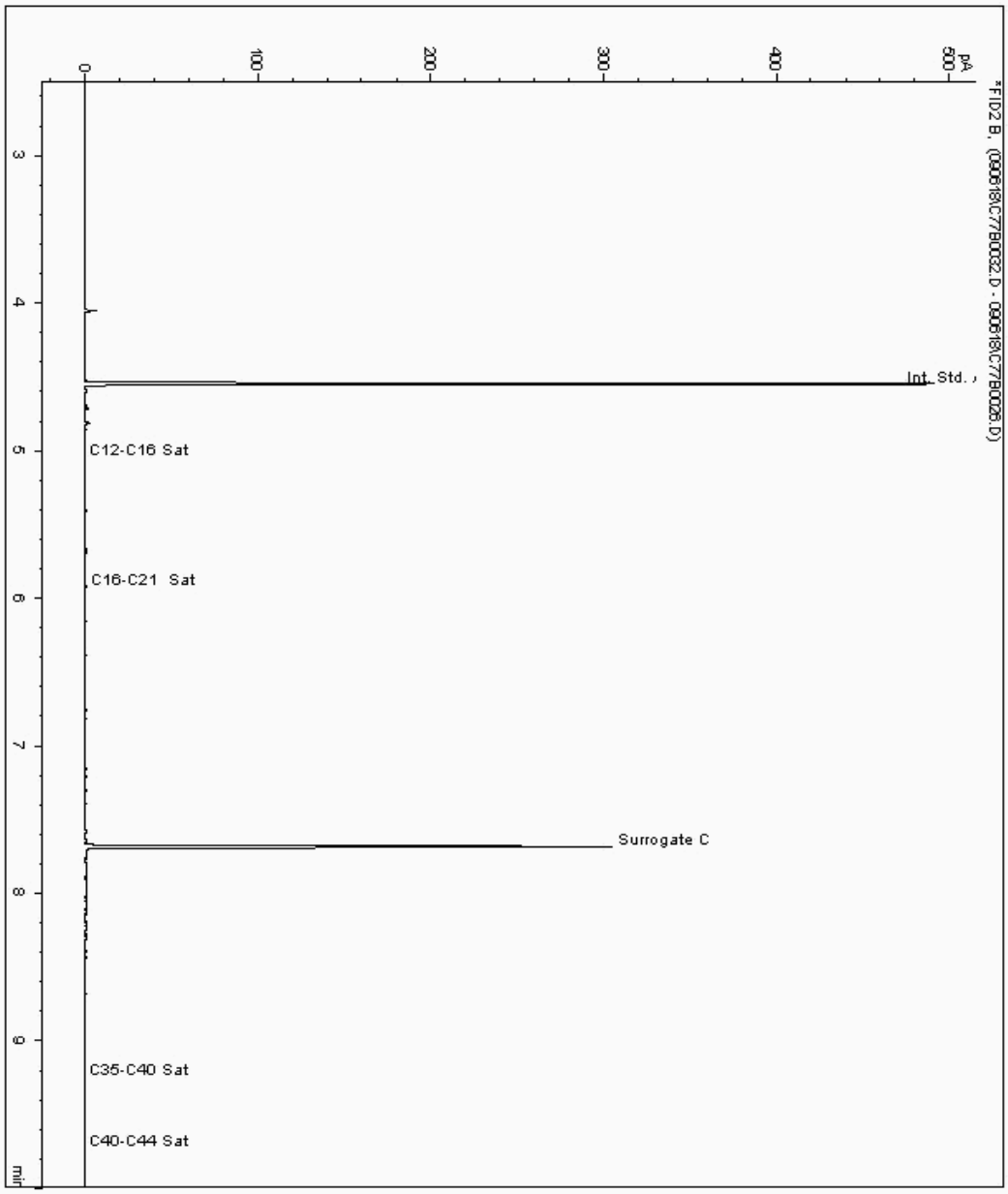
SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Chromatogram

Analysis: EPH CWG (Aliphatic) GC (S) **Sample No :** 18252811 **Depth :** 0.65 - 0.75
Sample ID : BH3

Alcontrol/Geochem Analytical Services
Speciated TPH - SATS (C12 - C40)

Sample Identity: 17146711-
Date Acquired : 9/7/2018 12:11:55 AM
Units : ppb
Dilution :
CF : 1
Multiplier : 0.980



CERTIFICATE OF ANALYSIS

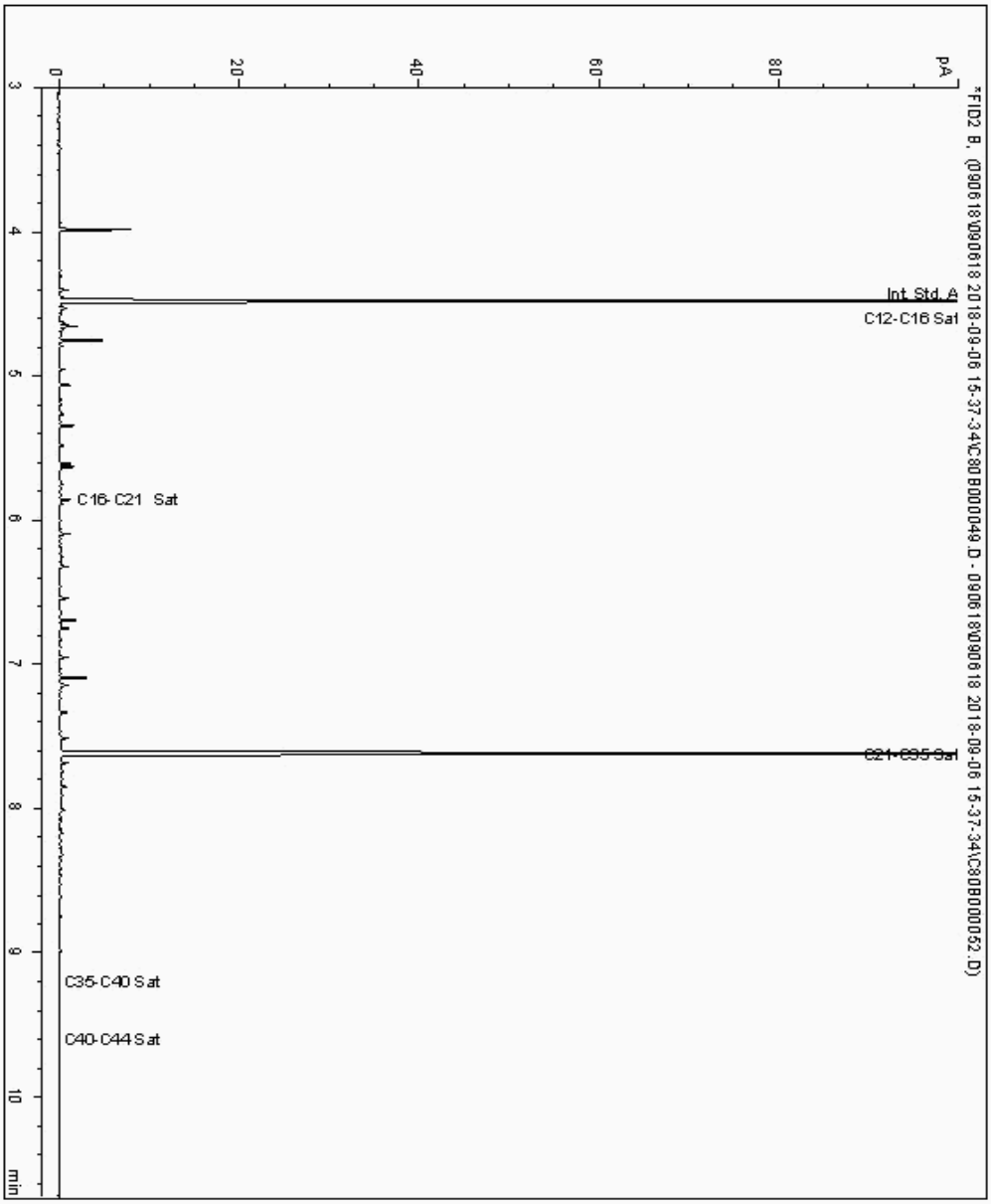
SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Chromatogram

Analysis: EPH CWG (Aliphatic) GC (S) **Sample No :** 18252858 **Depth :** 2.20 - 2.30
Sample ID : BH1

Alcontrol/Geochem Analytical Services
Speciated TPH - SATS (C12 - C40)

Sample Identity: 17146683-
Date Acquired : 07/09/18 06:17:08
Units : ppb
Dilution :
CF : 1
Multiplier : 1.020

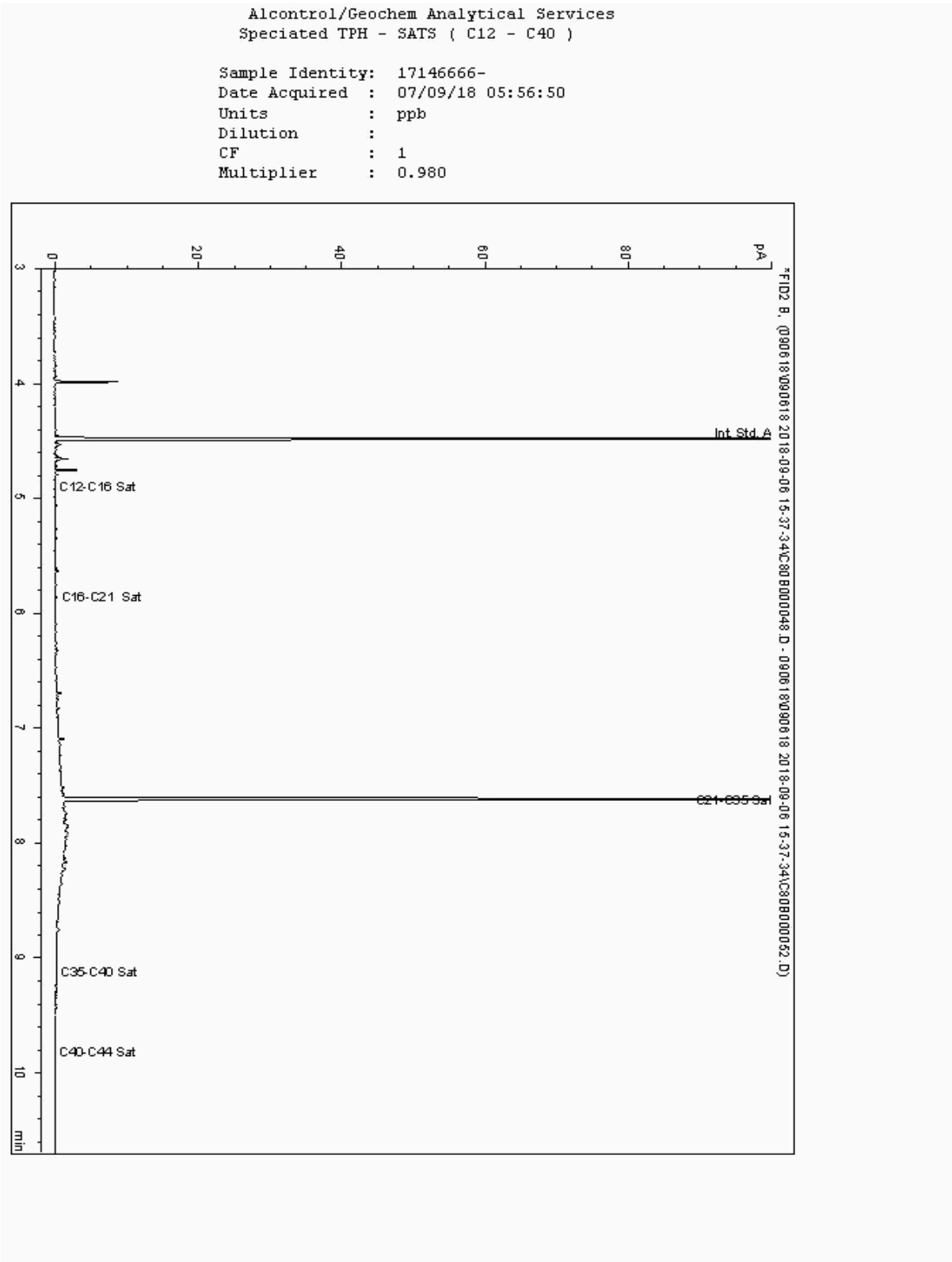


CERTIFICATE OF ANALYSIS

SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Chromatogram

Analysis: EPH CWG (Aliphatic) GC (S) **Sample No :** 18252924 **Depth :** 0.80 - 0.90
Sample ID : BH1



CERTIFICATE OF ANALYSIS

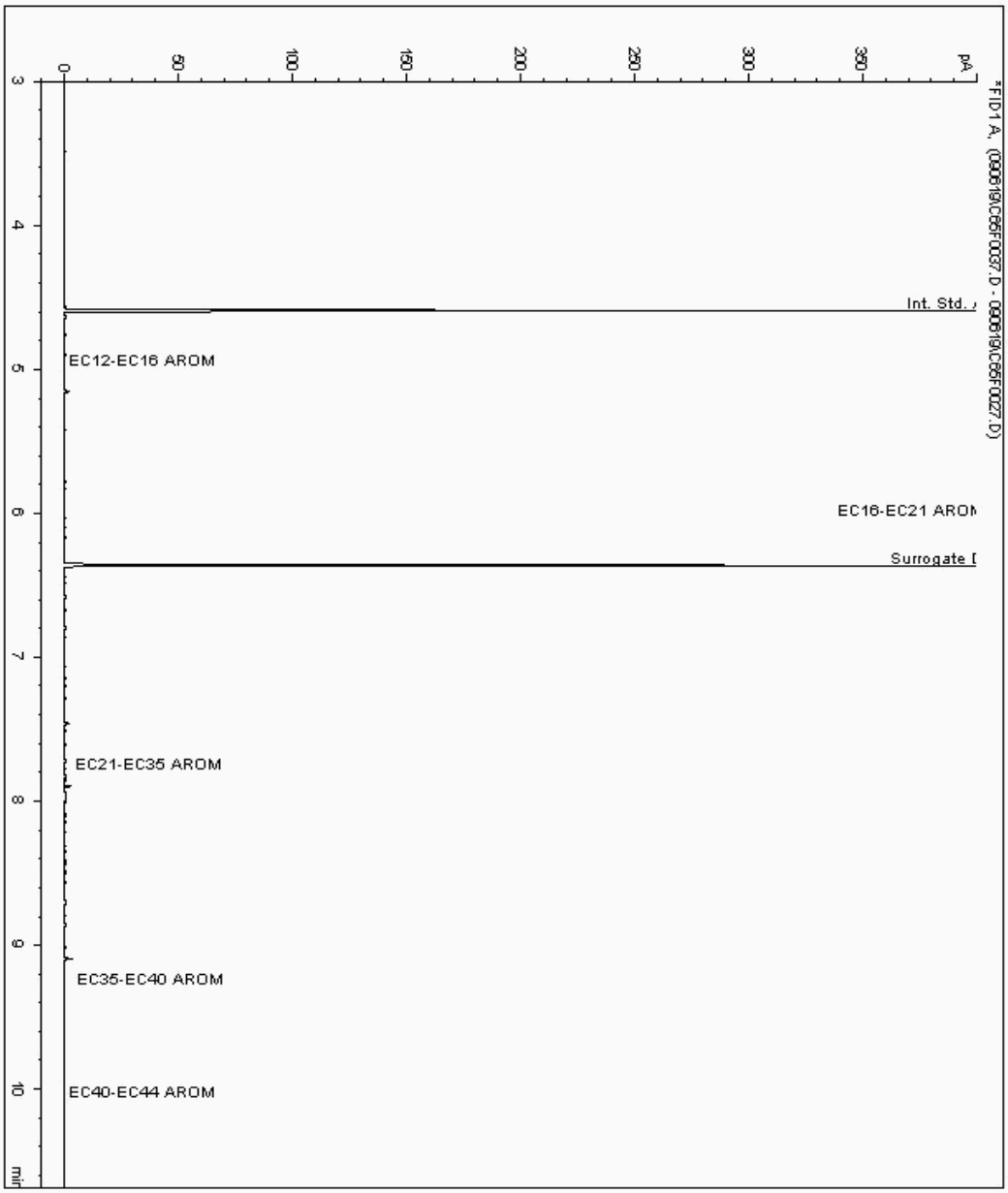
SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Chromatogram

Analysis: EPH CWG (Aromatic) GC (S) **Sample No :** 18250335 **Depth :** 0.70 - 0.80
Sample ID : BH2

Speciated TPH - AROM (C12 - C40)

Sample Identity: 17142340-
Date Acquired : 07/09/2018 00:31:41 PM
Units : ppb
Dilution: BH2[0.70 - 0.80] ->



CERTIFICATE OF ANALYSIS

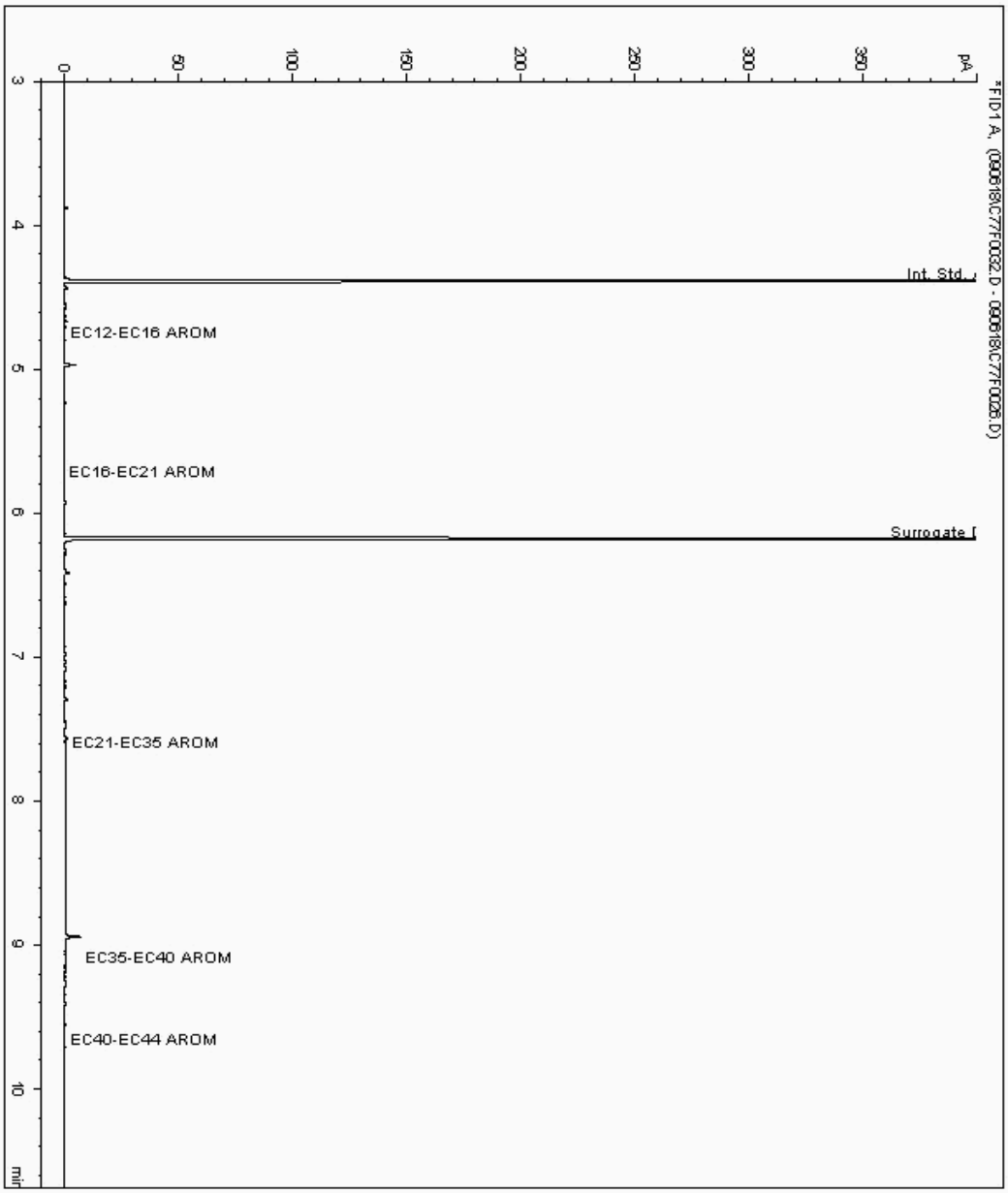
SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Chromatogram

Analysis: EPH CWG (Aromatic) GC (S) **Sample No :** 18252811 **Depth :** 0.65 - 0.75
Sample ID : BH3

Speciated TPH - AROM (C12 - C40)

Sample Identity: 17146712-
Date Acquired : 9/7/2018 12:11:55 AM
Units : ppb
Dilution:



CERTIFICATE OF ANALYSIS

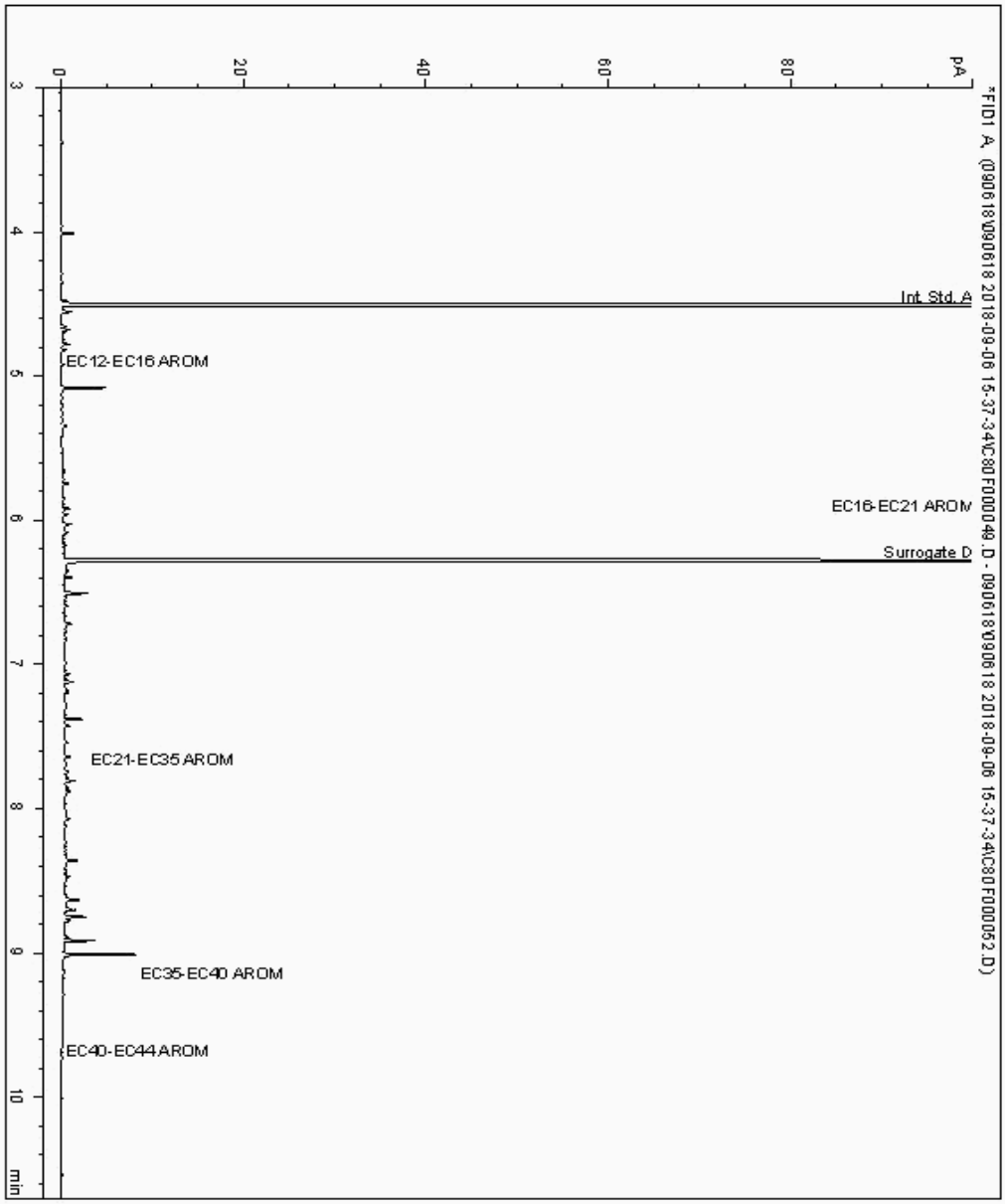
SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Chromatogram

Analysis: EPH CWG (Aromatic) GC (S) **Sample No :** 18252858 **Sample ID :** BH1 **Depth :** 2.20 - 2.30

Speciated TPH - AROMS (C12 - C44)

Sample Identity: 17146684-
Date Acquired : 07/09/18 06:17:08
Units : ppb
Dilution :
CF : 1
Multiplier : 1.020



CERTIFICATE OF ANALYSIS

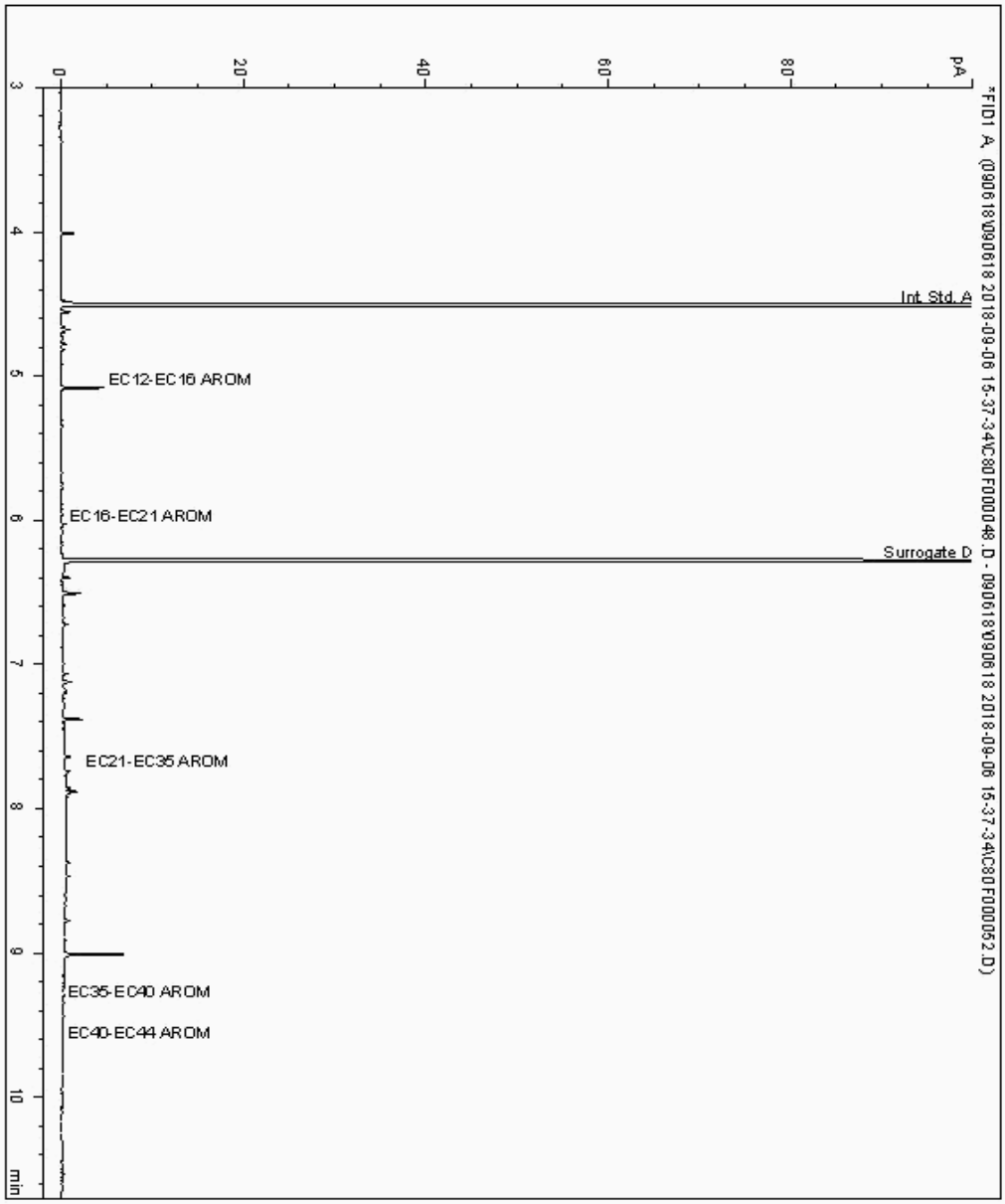
SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Chromatogram

Analysis: EPH CWG (Aromatic) GC (S) **Sample No :** 18252924 **Sample ID :** BH1 **Depth :** 0.80 - 0.90

Speciated TPH - AROMS (C12 - C44)

Sample Identity: 17146667-
Date Acquired : 07/09/18 05:56:50
Units : ppb
Dilution :
CF : 1
Multiplier : 0.980



CERTIFICATE OF ANALYSIS

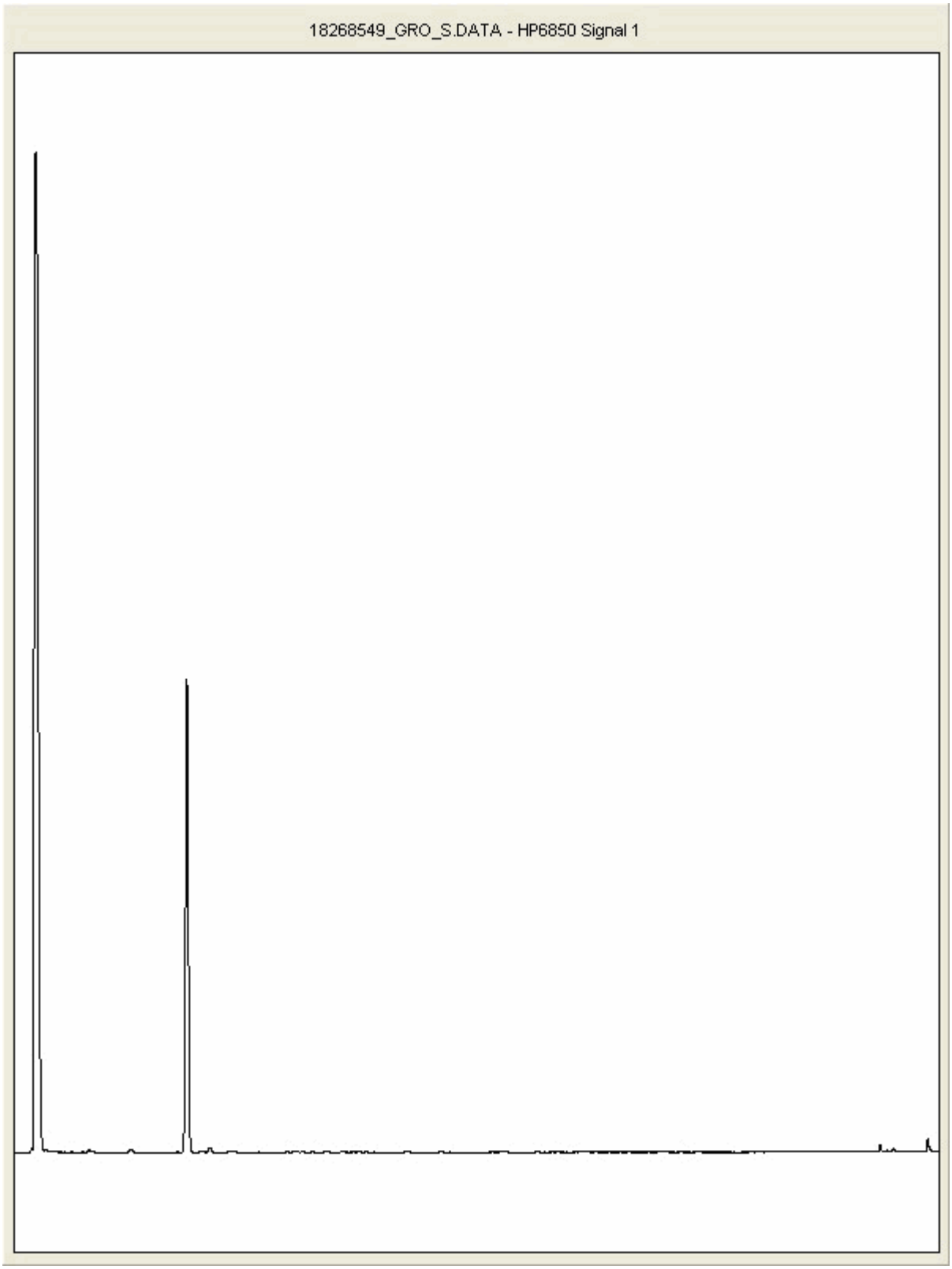
SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Chromatogram

Analysis: GRO by GC-FID (S)

Sample No : 18268549
Sample ID : BH1

Depth : 2.20 - 2.30



CERTIFICATE OF ANALYSIS

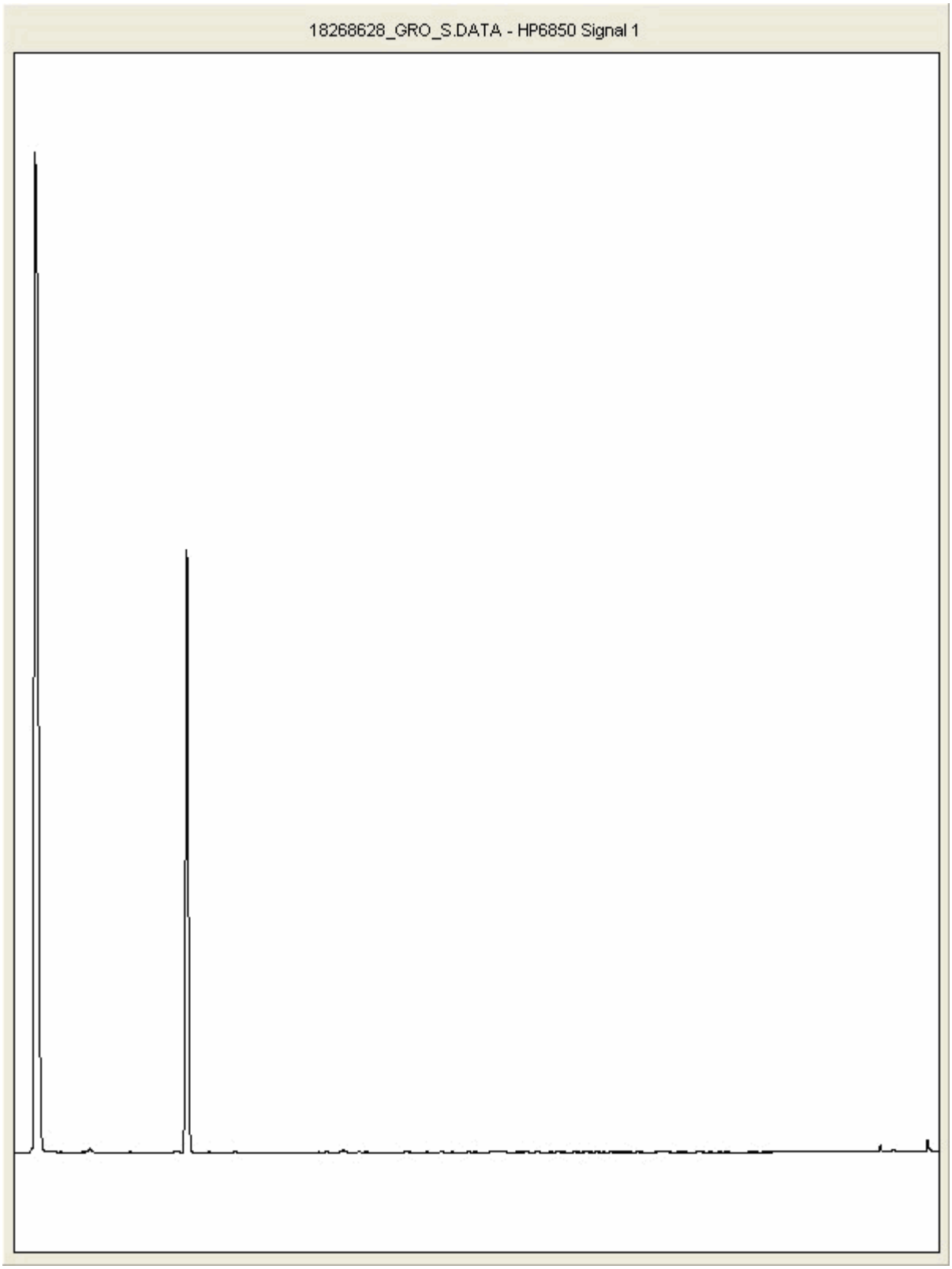
SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Chromatogram

Analysis: GRO by GC-FID (S)

Sample No : 18268628
Sample ID : BH3

Depth : 0.65 - 0.75



CERTIFICATE OF ANALYSIS

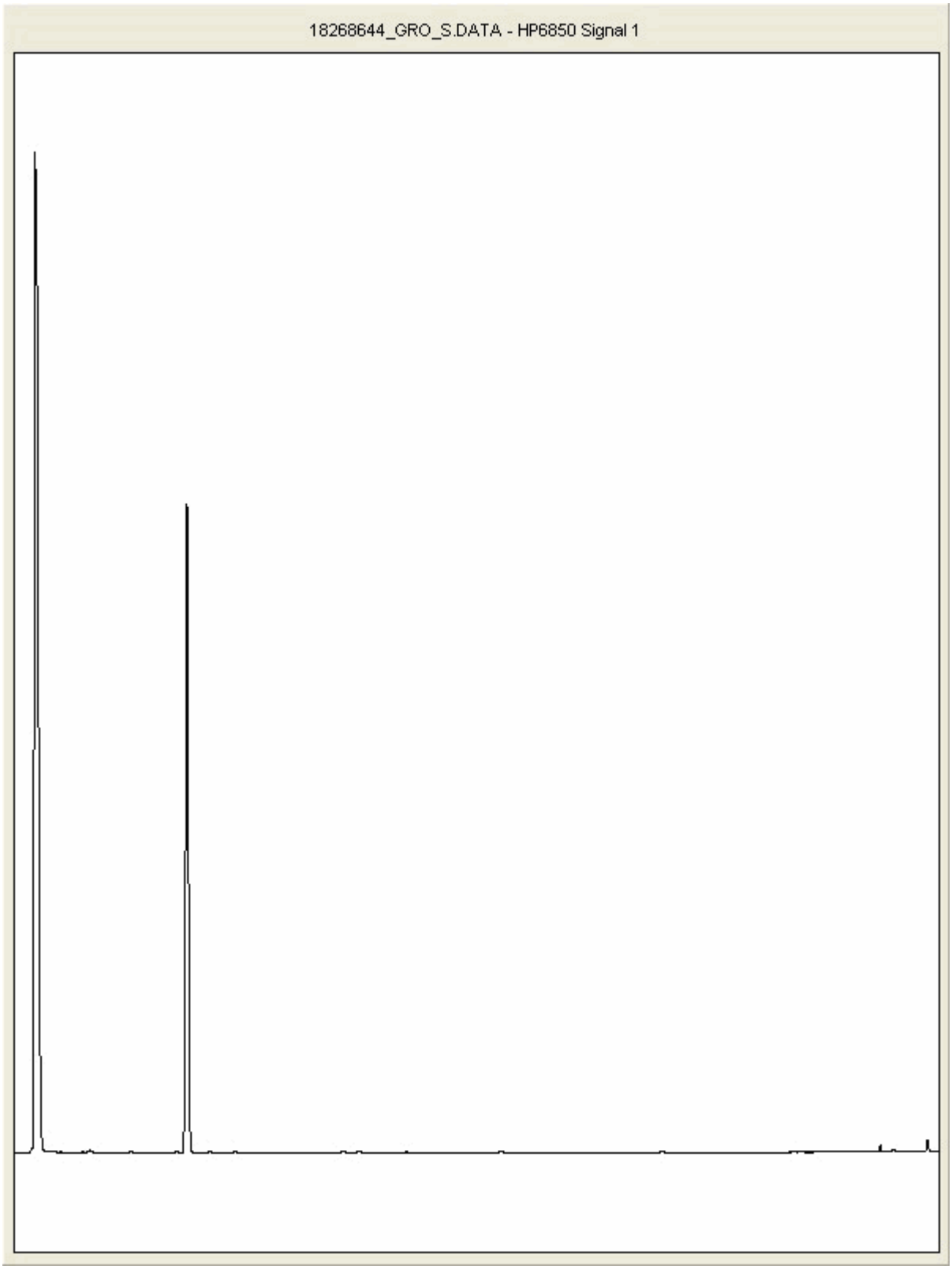
SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Chromatogram

Analysis: GRO by GC-FID (S)

Sample No : 18268644
Sample ID : BH1

Depth : 0.80 - 0.90



CERTIFICATE OF ANALYSIS

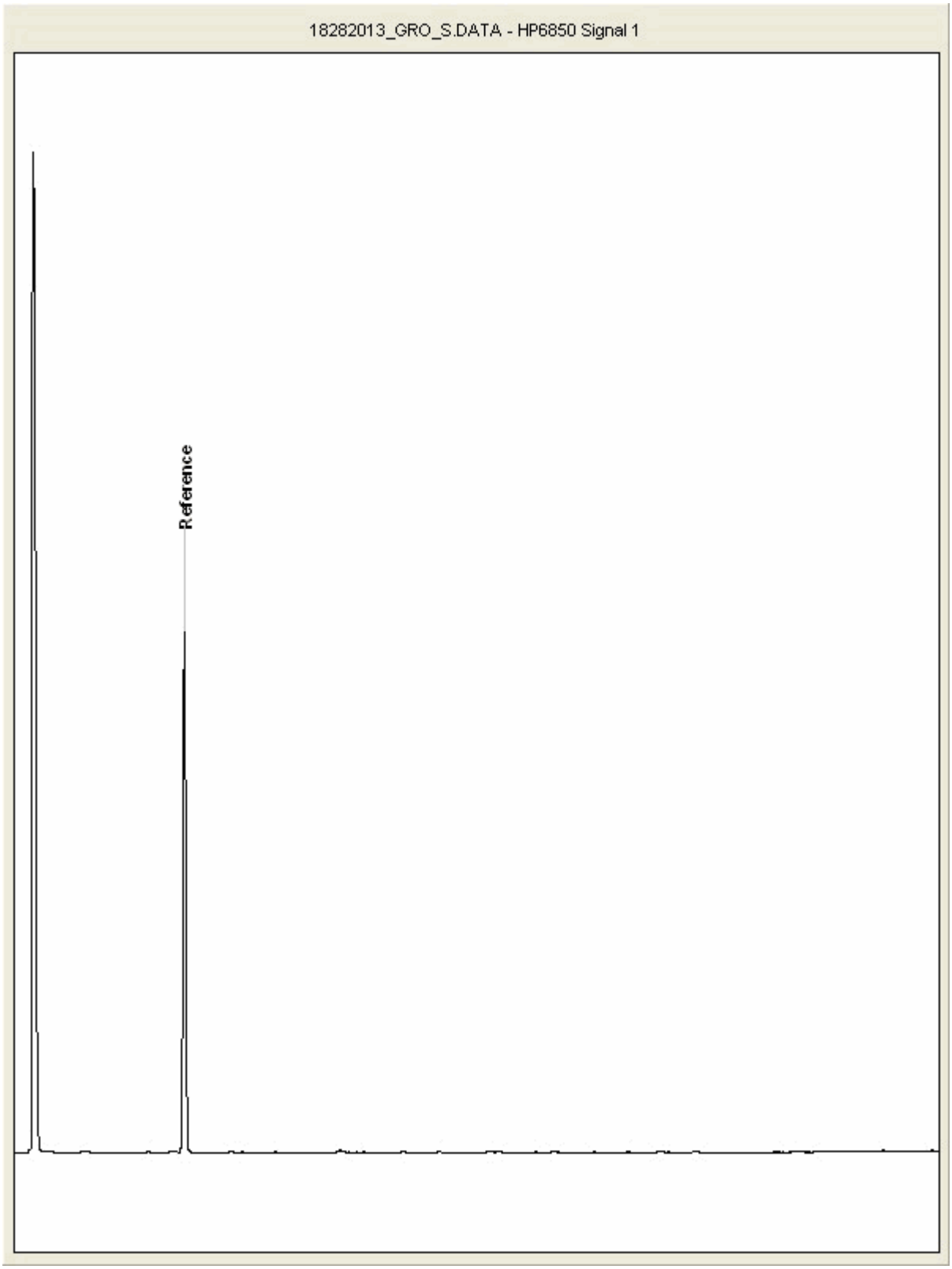
SDG:	180903-58	**Client Reference:**	70048625 - Project RED	**Report Number:**	472235
Location:	MRI - Project RED	**Order Number:**	70048625-S01	**Superseded Report:**	472008

Chromatogram

Analysis: GRO by GC-FID (S)

Sample No : 18282013
Sample ID : BH2

Depth : 0.70 - 0.80



Appendix

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICs and SVOC TICs.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALS reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as “Not detected”. If no asbestos fibre types are found all will be reported as “Not detected” and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible (NDP). The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP - No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals - total metals must be requested separately.

11. Results relate only to the items tested.

12. LoDs (Limit of Detection) for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** - Surrogates are added to your sample to monitor recovery of the test requested. A % recovery is reported, results are not corrected for the recovery measured. Typical recoveries for organics tests are 70-130%. Recoveries in soils are affected by organic rich or clay rich matrices. Waters can be affected by remediation fluids or high amounts of sediment. Test results are only ever reported if all of the associated quality checks pass; it is assumed that all recoveries outside of the values above are due to matrix affect.

14. **Product analyses** - Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For leachate preparations other than Zero Headspace Extraction (ZHE) volatile loss may occur.

General

21. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

24. **Tentatively Identified Compounds (TICs)** are non-target peaks in VOC and SVOC analysis. All non-target peaks detected with a concentration above the LoD are subjected to a mass spectral library search. Non-target peaks with a library search confidence of >75% are reported based on the best mass spectral library match. When a non-target peak with a library search confidence of <75% is detected it is reported as “mixed hydrocarbons”. Non-target compounds identified from the scan data are semi-quantified relative to one of the deuterated internal standards, under the same chromatographic conditions as the target compounds. This result is reported as a semi-quantitative value and reported as Tentatively Identified Compounds (TICs). TICs are outside the scope of UKAS accreditation and are not moisture corrected.

Sample Deviations

If a sample is classed as deviated then the associated results may be compromised.

1	**Container with Headspace provided for volatiles analysis**
2	**Incorrect container received**
3	**Deviation from method**
4	**Holding time exceeded before sample received**
5	**Samples exceeded holding time before presevation was performed**
§	**Sampled on date not provided**
♦	**Sample holding time exceeded in laboratory**
@	**Sample holding time exceeded due to sampled on date**
&	**Sample Holding Time exceeded - Late arrival of instructions.**

Asbestos

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than: - Trace - Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

Unit 7-8 Hawarden Business Park
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Website: www.alsenvironmental.co.uk

WSP PB MLN
The Victoria
150-182 The Quays
Salford
Manchester
Lancashire
M50 3SP

Attention: Emily Morgan

CERTIFICATE OF ANALYSIS

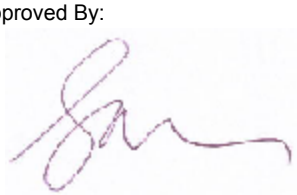
Date:	17 September 2018
Customer:	H_WSP_MAN
Sample Delivery Group (SDG):	180911-39
Your Reference:	MRI - Porject RED
Location:	Manchester Royal Infirmary
Report No:	472639

We received 2 samples on Friday September 07, 2018 and 2 of these samples were scheduled for analysis which was completed on Monday September 17, 2018. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

Chemical testing (unless subcontracted) performed at ALS Environmental Hawarden (Method codes TM) or ALS Environmental Aberdeen (Method codes S).

Approved By:



Sonia McWhan

Operations Manager

1291

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CERTIFICATE OF ANALYSIS

SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
18301149	BH1	EW	0.00 - 0.00	06/09/2018
18301154	BH2	EW	0.00 - 0.00	06/09/2018

Maximum Sample/Coolbox Temperature (°C) : **15.8**

ISO5667-3 Water quality - Sampling - Part3 -
During Transportation samples shall be stored in a cooling device capable of maintaining a temperature of (5±3)°C.

ALS have data which show that a cool box with 4 frozen icepacks is capable of maintaining pre-chilled samples at a temperature of (5±3)°C for a period of up to 24hrs.

Only received samples which have had analysis scheduled will be shown on the following pages.

CERTIFICATE OF ANALYSIS

SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

Results Legend

X **Test**

N **No Determination Possible**

Sample Types -
S - Soil/Solid
UNS - Unspecified Solid
GW - Ground Water
SW - Surface Water
LE - Land Leachate
PL - Prepared Leachate
PR - Process Water
SA - Saline Water
TE - Trade Effluent
TS - Treated Sewage
US - Untreated Sewage
RE - Recreational Water
DW - Drinking Water Non-regulatory
UNL - Unspecified Liquid
SL - Sludge
G - Gas
OTH - Other

Lab Sample No(s)			18301149				18301154				
Customer Sample Reference			BH1				BH2				
AGS Reference			EW				EW				
Depth (m)			0.00 - 0.00				0.00 - 0.00				
Container			1000ml glass bottle (ALE220)	1lplastic (ALE221)	Vial (ALE297)	1000ml glass bottle (ALE220)	1lplastic (ALE221)	Vial (ALE297)			
Sample Type			GW	GW	GW	GW	GW	GW			
Anions by Kone (w)	All	NDPs: 0 Tests: 2		X			X				
EPH CWG (Aliphatic) Aqueous GC (W)	All	NDPs: 0 Tests: 2	X			X					
EPH CWG (Aromatic) Aqueous GC (W)	All	NDPs: 0 Tests: 2	X			X					
GRO by GC-FID (W)	All	NDPs: 0 Tests: 2			X			X			
Mercury Unfiltered	All	NDPs: 0 Tests: 2		X			X				
PAH Spec MS - Aqueous (W)	All	NDPs: 0 Tests: 2	X			X					
pH Value	All	NDPs: 0 Tests: 2		X			X				
Total Metals by ICP-MS	All	NDPs: 0 Tests: 2		X			X				
TPH CWG (W)	All	NDPs: 0 Tests: 2	X			X					
VOC MS (W)	All	NDPs: 0 Tests: 2			X			X			

Validated

CERTIFICATE OF ANALYSIS

SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH2				
			Depth (m)	0.00 - 0.00	0.00 - 0.00				
			Sample Type	Ground Water (GW)	Ground Water (GW)				
			Date Sampled	06/09/2018	06/09/2018				
			Sampled Time	.	.				
			Date Received	07/09/2018	07/09/2018				
			SDG Ref	180911-39	180911-39				
			Lab Sample No.(s)	18301149	18301154				
			AGS Reference	EW	EW				
Arsenic (tot.unfilt)	<2 µg/l	TM152		46.9 2 #	86.3 2 #				
Cadmium (tot.unfilt)	<0.5 µg/l	TM152		7.19 2 #	6.17 2 #				
Chromium (tot.unfilt)	<3 µg/l	TM152		634 2 #	875 2 #				
Copper (tot.unfilt)	<1 µg/l	TM152		514 2 #	905 2 #				
Lead (tot.unfilt)	<1 µg/l	TM152		430 2 #	634 2 #				
Nickel (tot.unfilt)	<1 µg/l	TM152		999 2 #	1090 2 #				
Selenium (tot.unfilt)	<1 µg/l	TM152		49.4 2 #	53.4 2 #				
Zinc (tot.unfilt)	<5 µg/l	TM152		1640 2 #	2010 2 #				
Mercury (tot.unfilt)	<0.02 µg/l	TM183		0.134 2 #	0.202 2 #				
Sulphate	<2000 µg/l	TM184		44400 #	232000 #				
pH	<1 pH Units	TM256		7.48 #	7.66 #				

CERTIFICATE OF ANALYSIS

SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

PAH Spec MS - Aqueous (W)

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH2				
			Depth (m)	0.00 - 0.00	0.00 - 0.00				
			Sample Type	Ground Water (GW)	Ground Water (GW)				
			Date Sampled	06/09/2018	06/09/2018				
			Sampled Time	.	.				
			Date Received	07/09/2018	07/09/2018				
			SDG Ref	180911-39	180911-39				
			Lab Sample No.(s)	18301149	18301154				
			AGS Reference	EW	EW				
Naphthalene (aq)	<0.01 µg/l	TM178		0.108	0.376				
Acenaphthene (aq)	<0.005 µg/l	TM178		<0.05	0.148				
Acenaphthylene (aq)	<0.005 µg/l	TM178		<0.05	<0.05				
Fluoranthene (aq)	<0.005 µg/l	TM178		0.484	1.14				
Anthracene (aq)	<0.005 µg/l	TM178		0.0851	0.118				
Phenanthrene (aq)	<0.005 µg/l	TM178		0.997	1.4				
Fluorene (aq)	<0.005 µg/l	TM178		0.0738	0.289				
Chrysene (aq)	<0.005 µg/l	TM178		0.248	0.847				
Pyrene (aq)	<0.005 µg/l	TM178		0.588	1.51				
Benzo(a)anthracene (aq)	<0.005 µg/l	TM178		0.142	0.468				
Benzo(b)fluoranthene (aq)	<0.005 µg/l	TM178		0.289	0.986				
Benzo(k)fluoranthene (aq)	<0.005 µg/l	TM178		0.0796	0.508				
Benzo(a)pyrene (aq)	<0.002 µg/l	TM178		0.124	0.707				
Dibenzo(a,h)anthracene (aq)	<0.005 µg/l	TM178		<0.05	<0.05				
Benzo(g,h,i)perylene (aq)	<0.005 µg/l	TM178		0.222	0.832				
Indeno(1,2,3-cd)pyrene (aq)	<0.005 µg/l	TM178		0.0904	0.519				
PAH, Total Detected USEPA 16 (aq)	<0.082 µg/l	TM178		3.53	9.85				

CERTIFICATE OF ANALYSIS

SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

TPH CWG (W)

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH2				
			Depth (m)	0.00 - 0.00	0.00 - 0.00				
			Sample Type	Ground Water (GW)	Ground Water (GW)				
			Date Sampled	06/09/2018	06/09/2018				
			Sampled Time	.	.				
			Date Received	07/09/2018	07/09/2018				
			SDG Ref	180911-39	180911-39				
			Lab Sample No.(s)	18301149	18301154				
			AGS Reference	EW	EW				
GRO Surrogate % recovery**	%	TM245		111	122				
GRO >C5-C12	<50 µg/l	TM245		<50 #	<50 #				
Aliphatics >C5-C6	<10 µg/l	TM245		<10	<10				
Aliphatics >C6-C8	<10 µg/l	TM245		<10	<10				
Aliphatics >C8-C10	<10 µg/l	TM245		<10	<10				
Aliphatics >C10-C12	<10 µg/l	TM245		<10	<10				
Aliphatics >C12-C16 (aq)	<10 µg/l	TM174		<100	109				
Aliphatics >C16-C21 (aq)	<10 µg/l	TM174		<100	711				
Aliphatics >C21-C35 (aq)	<10 µg/l	TM174		509	12800				
Total Aliphatics >C12-C35 (aq)	<10 µg/l	TM174		509	13600				
Aromatics >EC5-EC7	<10 µg/l	TM245		<10	<10				
Aromatics >EC7-EC8	<10 µg/l	TM245		<10	<10				
Aromatics >EC8-EC10	<10 µg/l	TM245		<10	<10				
Aromatics >EC10-EC12	<10 µg/l	TM245		<10	<10				
Aromatics >EC12-EC16 (aq)	<10 µg/l	TM174		<100	<100				
Aromatics >EC16-EC21 (aq)	<10 µg/l	TM174		<100	268				
Aromatics >EC21-EC35 (aq)	<10 µg/l	TM174		<100	3720				
Total Aromatics >EC12-EC35 (aq)	<10 µg/l	TM174		<100	3990				
Total Aliphatics & Aromatics >C5-35 (aq)	<10 µg/l	TM174		509	17600				
Aliphatics >C16-C35 Aqueous	<10 µg/l	TM174		509	13500				
Aromatics >EC16-EC35 (aq)	<10 µg/l	TM174		<100	3990				

CERTIFICATE OF ANALYSIS

SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

VOC MS (W)

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH2			
			Depth (m)	0.00 - 0.00	0.00 - 0.00			
			Sample Type	Ground Water (GW)	Ground Water (GW)			
			Date Sampled	06/09/2018	06/09/2018			
			Sampled Time	.	.			
			Date Received	07/09/2018	07/09/2018			
			SDG Ref	180911-39	180911-39			
			Lab Sample No.(s)	18301149	18301154			
			AGS Reference	EW	EW			
Methyl tertiary butyl ether (MTBE)	<1 µg/l	TM208		<1 #	<1 #			
Benzene	<1 µg/l	TM208		<1 #	<1 #			
Toluene	<1 µg/l	TM208		<1 #	<1 #			
Ethylbenzene	<1 µg/l	TM208		<1 #	<1 #			
m,p-Xylene	<1 µg/l	TM208		<1 #	<1 #			
o-Xylene	<1 µg/l	TM208		<1 #	<1 #			
tert-Amyl methyl ether (TAME)	<1 µg/l	TM208		<1 #	<1 #			
Sum of detected Xylenes	<2 µg/l	TM208		<2	<2			

CERTIFICATE OF ANALYSIS

SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

Table of Results - Appendix

Method No	Reference	Description
TM061	Method for the Determination of EPH,Massachusetts Dept.of EP, 1998	Determination of Extractable Petroleum Hydrocarbons by GC-FID (C10-C40)
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS
TM174	Analysis of Petroleum Hydrocarbons in Environmental Media – Total Petroleum Hydrocarbon Criteria	Determination of Speciated Extractable Petroleum Hydrocarbons in Waters by GC-FID
TM178	Modified: US EPA Method 8100	Determination of Polynuclear Aromatic Hydrocarbons (PAH) by GC-MS in Waters
TM183	BS EN 23506:2002, (BS 6068-2.74:2002) ISBN 0 580 38924 3	Determination of Trace Level Mercury in Waters and Leachates by PSA Cold Vapour Atomic Fluorescence Spectrometry
TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers
TM208	Modified: US EPA Method 8260b & 624	Determination of Volatile Organic Compounds by Headspace / GC-MS in Waters
TM245	By GC-FID	Determination of GRO by Headspace in waters
TM256	The measurement of Electrical Conductivity and the Laboratory determination of pH Value of Natural, Treated and Wastewaters. HMSO, 1978. ISBN 011 751428 4.	Determination of pH in Water and Leachate using the GLpH pH Meter

NA = not applicable.

Chemical testing (unless subcontracted) performed at ALS Environmental Hawarden (Method codes TM) or ALS Environmental Aberdeen (Method codes S).

CERTIFICATE OF ANALYSIS

SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

Test Completion Dates

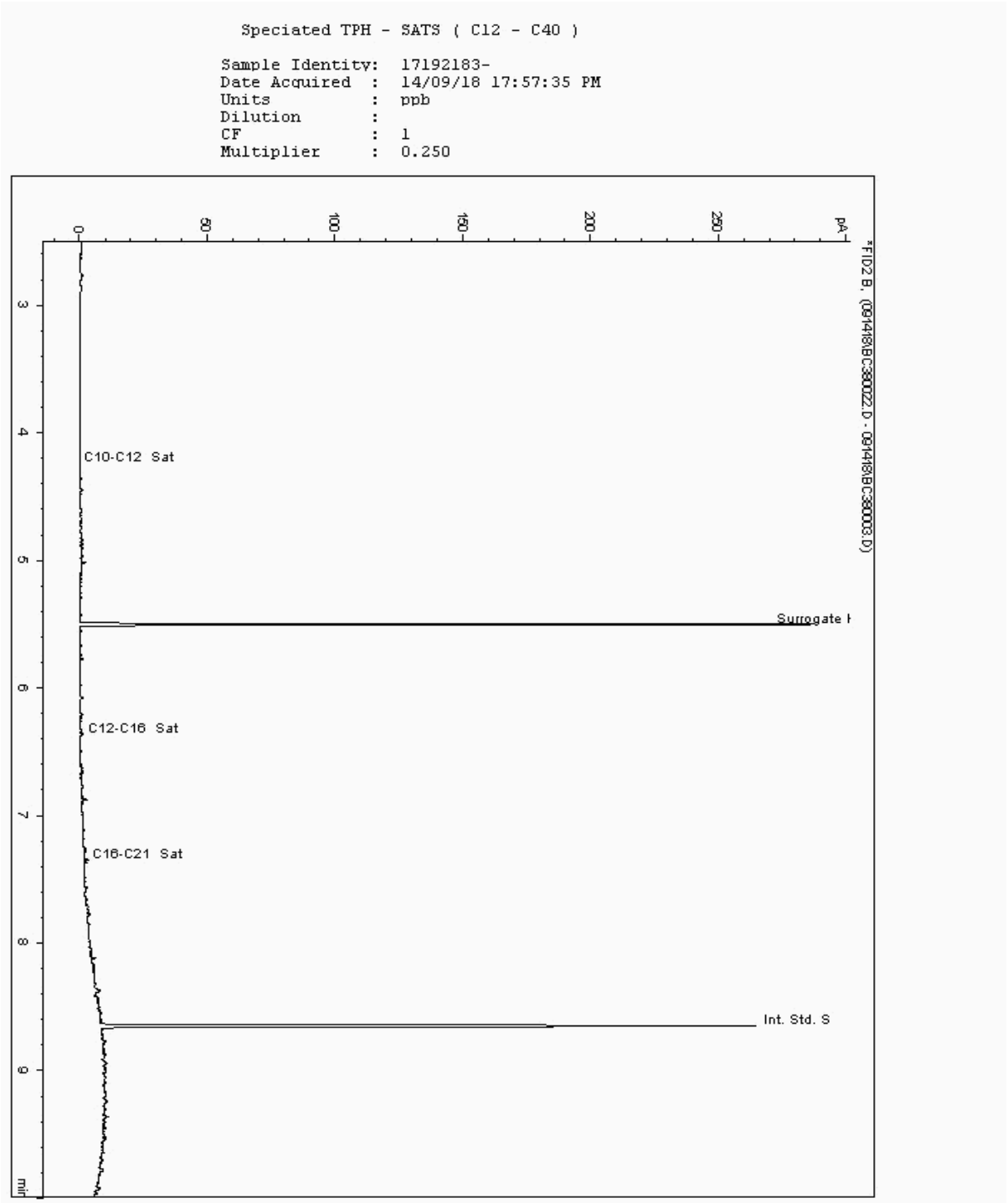
Lab Sample No(s)	18301149	18301154
Customer Sample Ref.	BH1	BH2
AGS Ref.	EW	EW
Depth	0.00 - 0.00	0.00 - 0.00
Type	Ground Water	Ground Water
Anions by Kone (w)	12-Sep-2018	12-Sep-2018
EPH CWG (Aliphatic) Aqueous GC (W)	17-Sep-2018	17-Sep-2018
EPH CWG (Aromatic) Aqueous GC (W)	17-Sep-2018	17-Sep-2018
GRO by GC-FID (W)	13-Sep-2018	13-Sep-2018
Mercury Unfiltered	14-Sep-2018	14-Sep-2018
PAH Spec MS - Aqueous (W)	13-Sep-2018	13-Sep-2018
pH Value	13-Sep-2018	13-Sep-2018
Total Metals by ICP-MS	13-Sep-2018	13-Sep-2018
TPH CWG (W)	17-Sep-2018	17-Sep-2018
VOC MS (W)	14-Sep-2018	14-Sep-2018

CERTIFICATE OF ANALYSIS

SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

Chromatogram

Analysis: EPH CWG (Aliphatic) Aqueous GC (W) **Sample No :** 18304714 **Depth :** 0.00 - 0.00
Sample ID : BH2



CERTIFICATE OF ANALYSIS

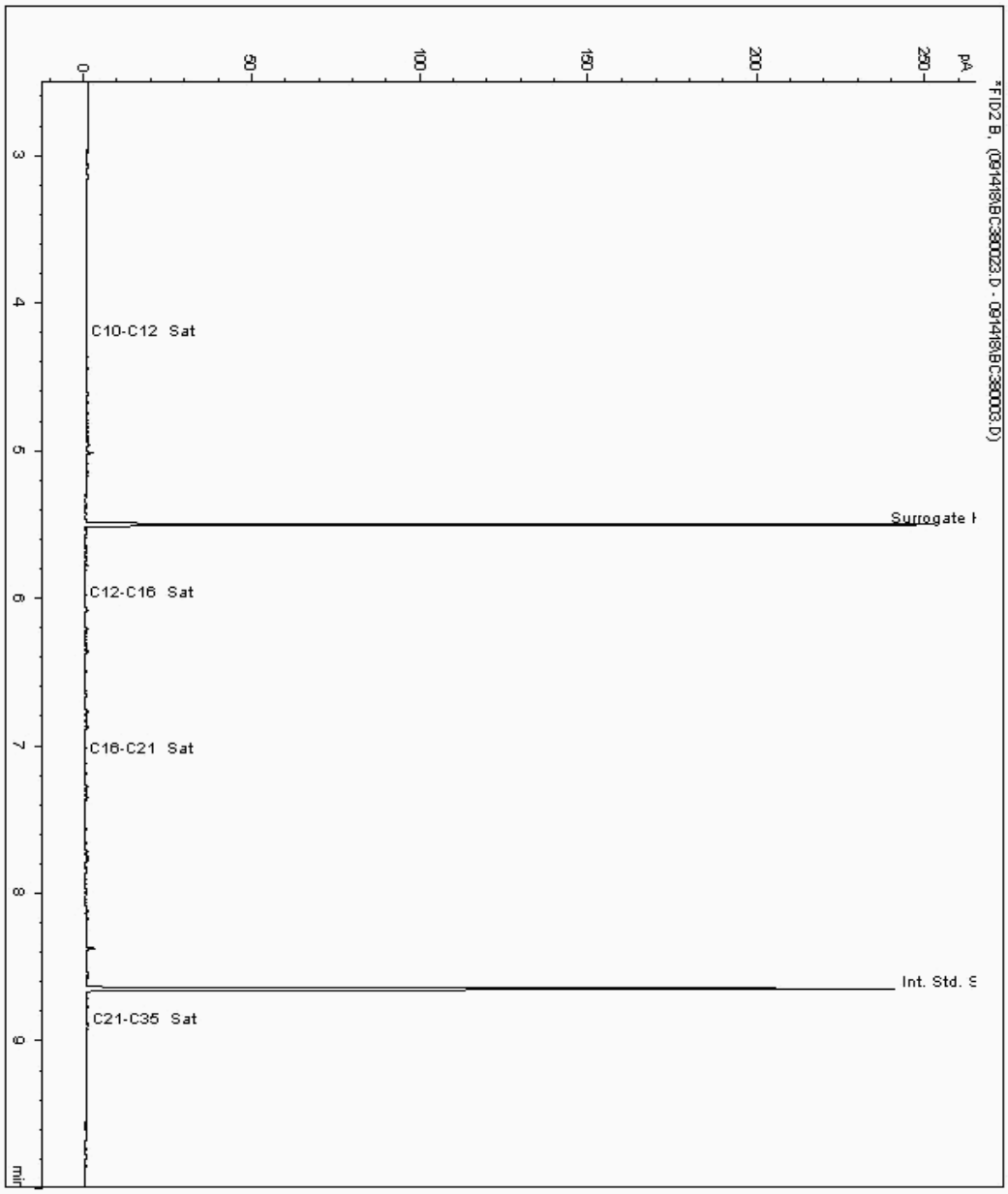
SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

Chromatogram

Analysis: EPH CWG (Aliphatic) Aqueous GC (W) **Sample No :** 18304725 **Depth :** 0.00 - 0.00
Sample ID : BH1

Speciated TPH - SATS (C12 - C40)

Sample Identity: 17192172-
Date Acquired : 14/09/18 18:20:59 PM
Units : ppb
Dilution :
CF : 1
Multiplier : 0.250

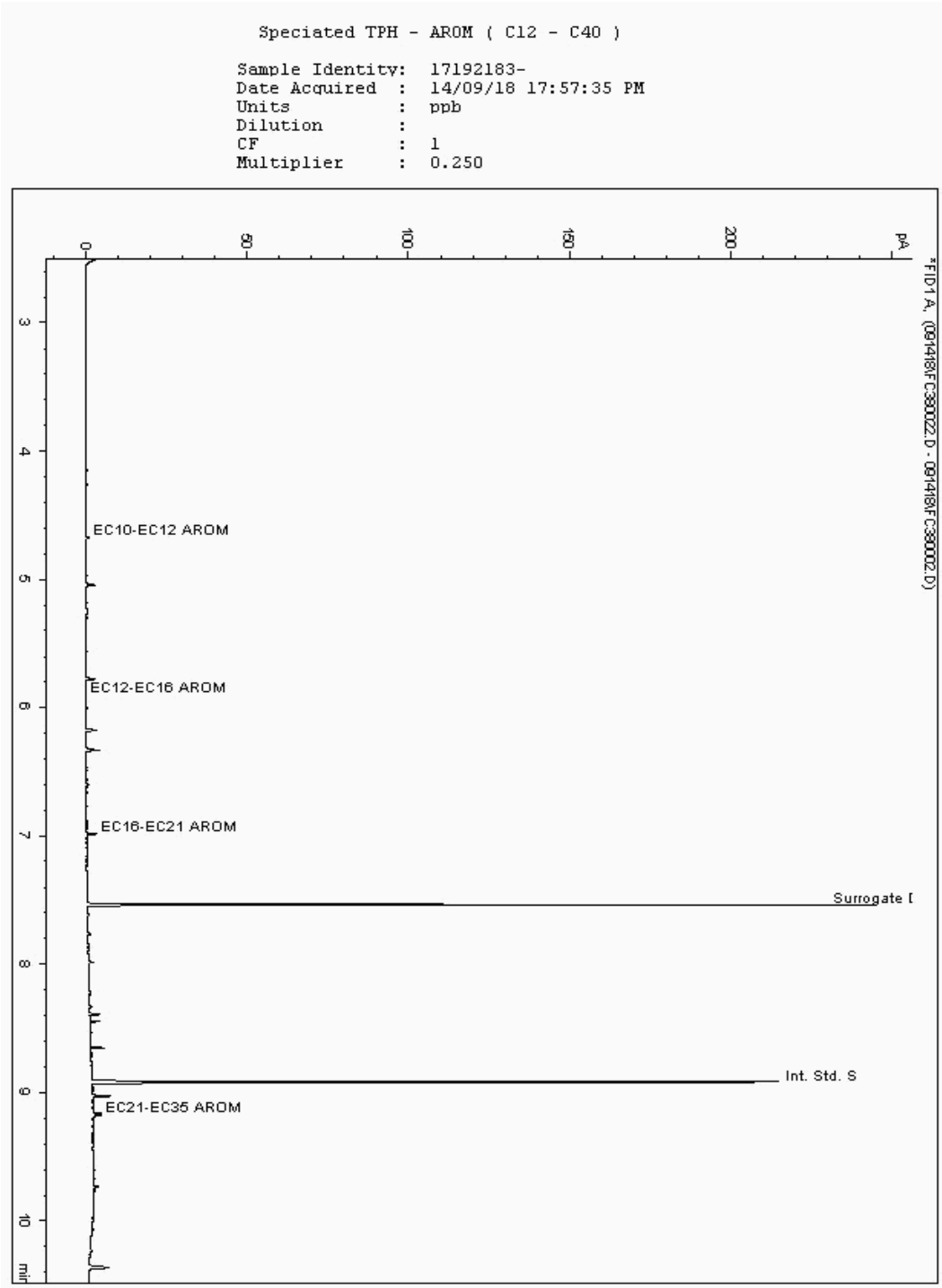


CERTIFICATE OF ANALYSIS

SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

Chromatogram

Analysis: EPH CWG (Aromatic) Aqueous GC (W) **Sample No :** 18304714 **Depth :** 0.00 - 0.00
Sample ID : BH2



CERTIFICATE OF ANALYSIS

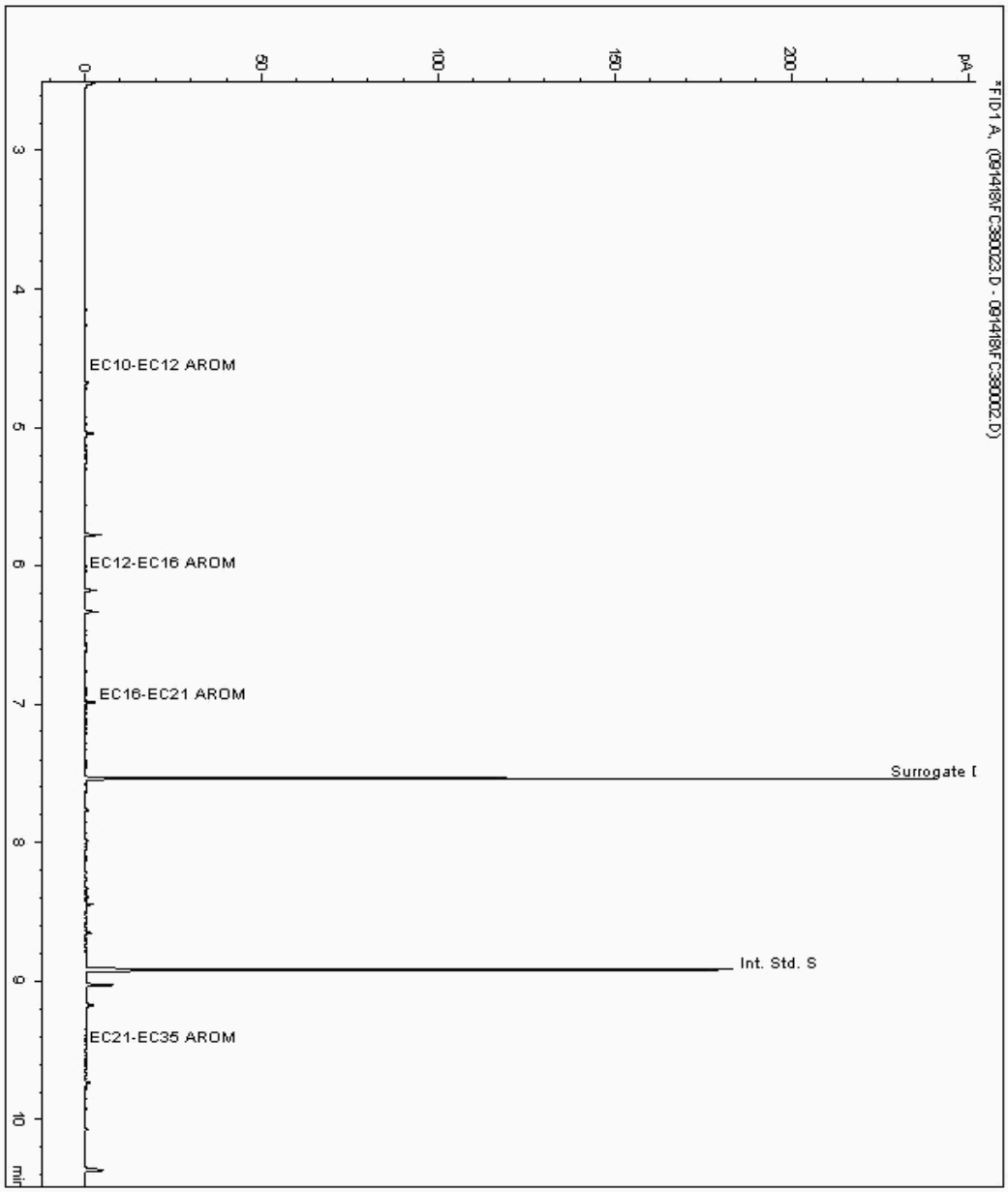
SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

Chromatogram

Analysis: EPH CWG (Aromatic) Aqueous GC (W) **Sample No :** 18304725 **Depth :** 0.00 - 0.00
Sample ID : BH1

Speciated TPH - AROM (C12 - C40)

Sample Identity: 17192172-
Date Acquired : 14/09/18 18:21:00 PM
Units : ppb
Dilution :
CF : 1
Multiplier : 0.250



CERTIFICATE OF ANALYSIS

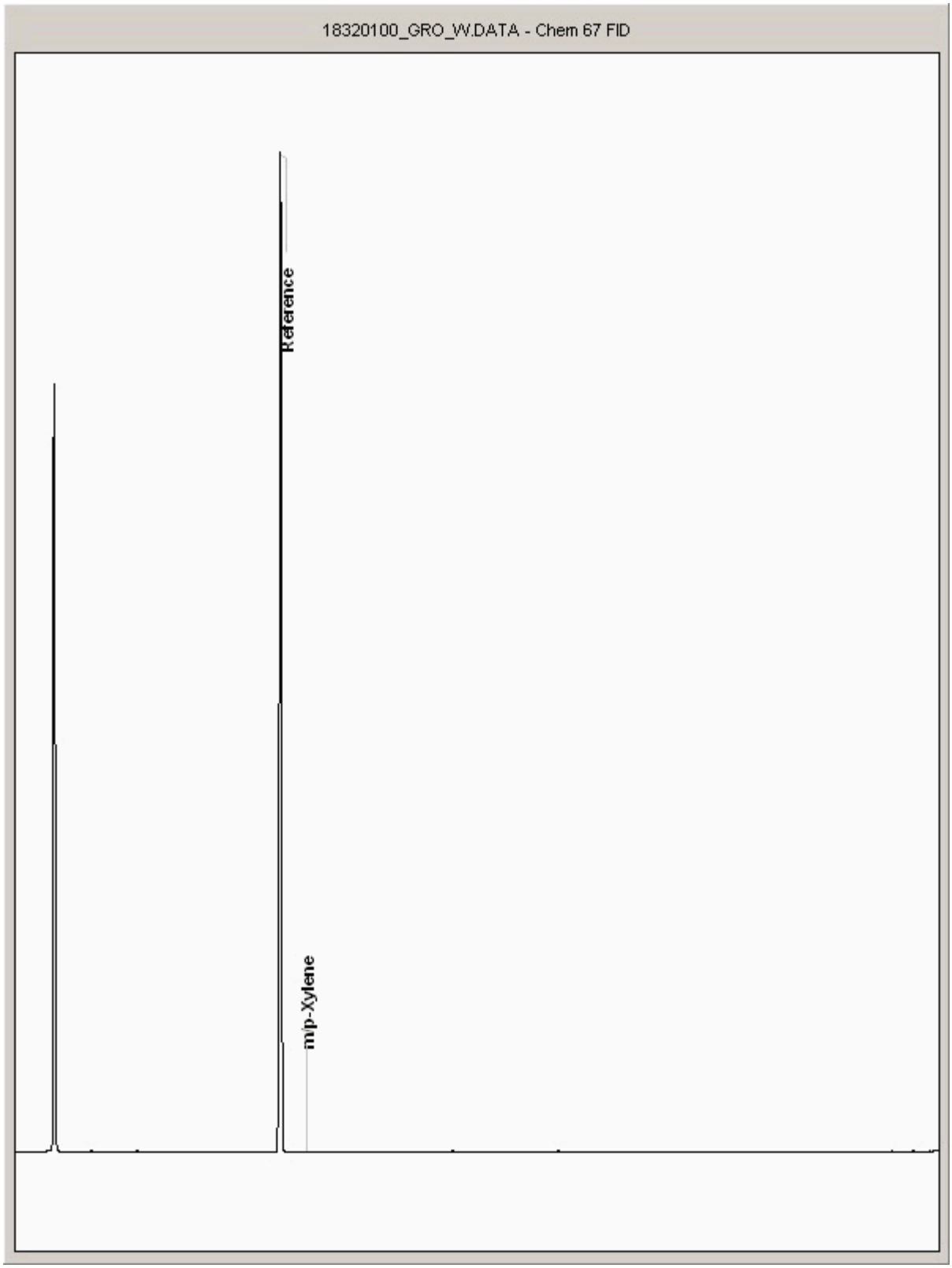
SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

Chromatogram

Analysis: GRO by GC-FID (W)

Sample No : 18320100
Sample ID : BH2

Depth : 0.00 - 0.00



CERTIFICATE OF ANALYSIS

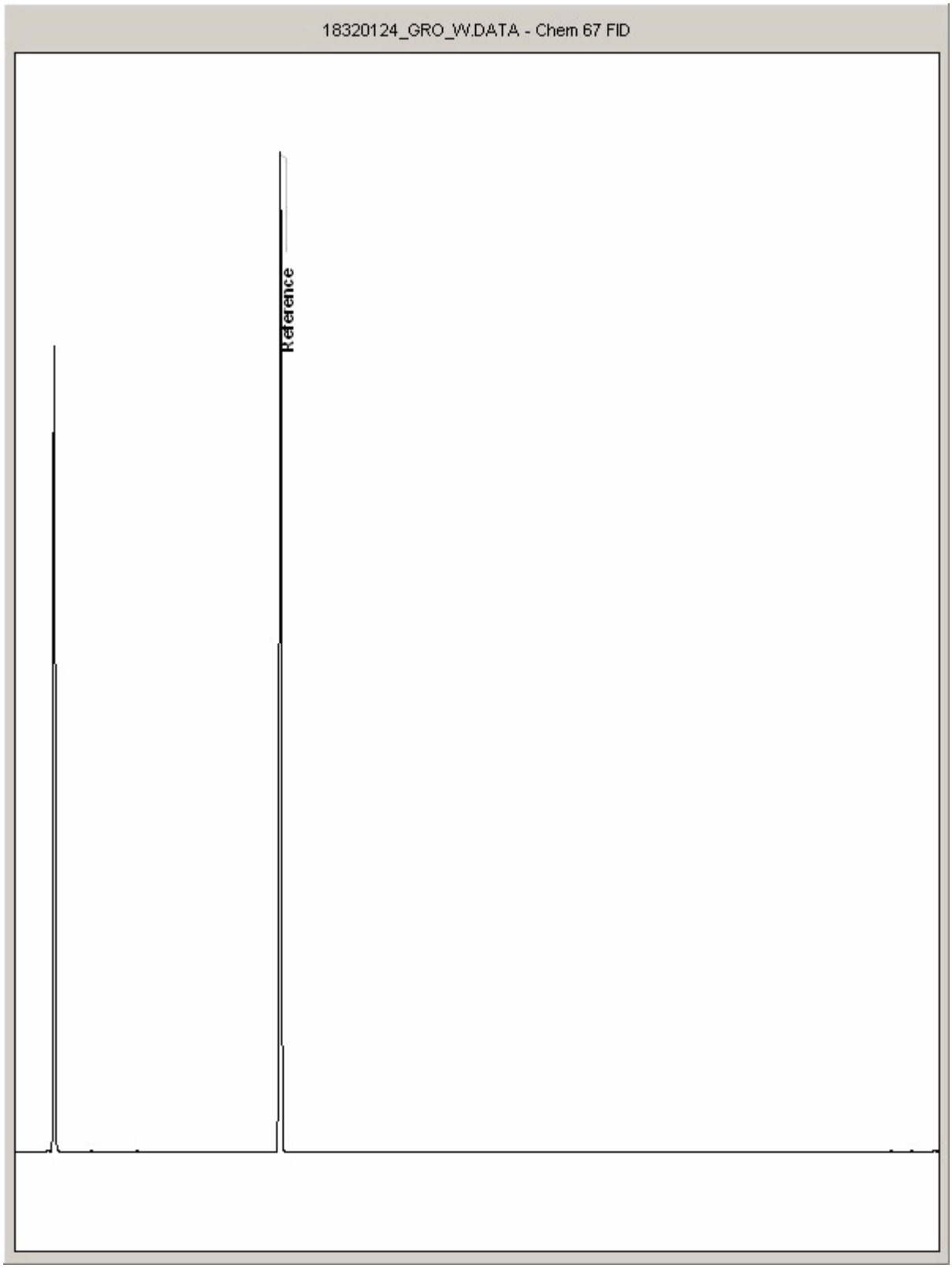
SDG:	180911-39	**Client Reference:**	MRI - Porject RED	**Report Number:**	472639
Location:	Manchester Royal Infirmar	**Order Number:**	70048625-S01	**Superseded Report:**	

Chromatogram

Analysis: GRO by GC-FID (W)

Sample No : 18320124
Sample ID : BH1

Depth : 0.00 - 0.00



Appendix

General

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICs and SVOC TICs.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALS reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as “Not detected”. If no asbestos fibre types are found all will be reported as “Not detected” and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible (NDP). The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP - No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals - total metals must be requested separately.

11. Results relate only to the items tested.

12. LoDs (Limit of Detection) for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** - Surrogates are added to your sample to monitor recovery of the test requested. A % recovery is reported, results are not corrected for the recovery measured. Typical recoveries for organics tests are 70-130%. Recoveries in soils are affected by organic rich or clay rich matrices. Waters can be affected by remediation fluids or high amounts of sediment. Test results are only ever reported if all of the associated quality checks pass; it is assumed that all recoveries outside of the values above are due to matrix affect.

14. **Product analyses** - Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For leachate preparations other than Zero Headspace Extraction (ZHE) volatile loss may occur.

21. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

24. **Tentatively Identified Compounds (TICs)** are non-target peaks in VOC and SVOC analysis. All non-target peaks detected with a concentration above the LoD are subjected to a mass spectral library search. Non-target peaks with a library search confidence of >75% are reported based on the best mass spectral library match. When a non-target peak with a library search confidence of <75% is detected it is reported as “mixed hydrocarbons”. Non-target compounds identified from the scan data are semi-quantified relative to one of the deuterated internal standards, under the same chromatographic conditions as the target compounds. This result is reported as a semi-quantitative value and reported as Tentatively Identified Compounds (TICs). TICs are outside the scope of UKAS accreditation and are not moisture corrected.

Sample Deviations

If a sample is classed as deviated then the associated results may be compromised.

1	**Container with Headspace provided for volatiles analysis**
2	**Incorrect container received**
3	**Deviation from method**
4	**Holding time exceeded before sample received**
5	**Samples exceeded holding time before presevation was performed**
§	**Sampled on date not provided**
♦	**Sample holding time exceeded in laboratory**
@	**Sample holding time exceeded due to sampled on date**
&	**Sample Holding Time exceeded - Late arrival of instructions.**

Asbestos

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than: - Trace - Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

Unit 7-8 Hawarden Business Park
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Hawarden
Deeside
CH5 3US
Tel: (01244) 528700
Fax: (01244) 528701
email: hawardencustomerservices@alsglobal.com
Website: www.alsenvironmental.co.uk

WSP PB MLN
The Victoria
150-182 The Quays
Salford
Manchester
Lancashire
M50 3SP

Attention: Emily Morgan

CERTIFICATE OF ANALYSIS

Date:	05 October 2018
Customer:	H_WSP_MAN
Sample Delivery Group (SDG):	180929-31
Your Reference:	MRI
Location:	MRI
Report No:	475525

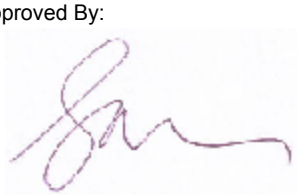
This report has been revised and directly supersedes 475282 in its entirety.

We received 2 samples on Saturday September 29, 2018 and 2 of these samples were scheduled for analysis which was completed on Friday October 05, 2018. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

Chemical testing (unless subcontracted) performed at ALS Environmental Hawarden (Method codes TM) or ALS Environmental Aberdeen (Method codes S).

Approved By:



Sonia McWhan

Operations Manager

ALS Environmental is part of ALS Life Sciences Limited. ALS Life Sciences Limited registered Office: Units 7 & 8 Hawarden Business Park, Manor Road, Hawarden, Deeside, CH5 3US. Registered in England and Wales No. 4057291.

CERTIFICATE OF ANALYSIS

SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
18427836	BH1	EW	0.00 - 0.00	25/09/2018
18427842	BH2	EW	0.00 - 0.00	25/09/2018

Maximum Sample/Coolbox Temperature (°C) : **6.8**

ISO5667-3 Water quality - Sampling - Part3 -
During Transportation samples shall be stored in a cooling device capable of maintaining a temperature of (5±3)°C.

ALS have data which show that a cool box with 4 frozen icepacks is capable of maintaining pre-chilled samples at a temperature of (5±3)°C for a period of up to 24hrs.

Only received samples which have had analysis scheduled will be shown on the following pages.

Validated

CERTIFICATE OF ANALYSIS

SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

Results Legend

X **Test**

N **No Determination Possible**

Sample Types -
S - Soil/Solid
UNS - Unspecified Solid
GW - Ground Water
SW - Surface Water
LE - Land Leachate
PL - Prepared Leachate
PR - Process Water
SA - Saline Water
TE - Trade Effluent
TS - Treated Sewage
US - Untreated Sewage
RE - Recreational Water
DW - Drinking Water Non-regulatory
UNL - Unspecified Liquid
SL - Sludge
G - Gas
OTH - Other

Lab Sample No(s)			18427836				18427842				
Customer Sample Reference			BH1				BH2				
AGS Reference			EW				EW				
Depth (m)			0.00 - 0.00				0.00 - 0.00				
Container			0.5l glass bottle (ALE227)	500ml Plastic (ALE208)	Vial (ALE297)	0.5l glass bottle (ALE227)	500ml Plastic (ALE208)	Vial (ALE297)			
Sample Type			GW	GW	GW	GW	GW	GW			
Anions by Kone (w)	All	NDPs: 0 Tests: 2		X			X				
EPH CWG (Aliphatic) Aqueous GC (W)	All	NDPs: 0 Tests: 2	X			X					
EPH CWG (Aromatic) Aqueous GC (W)	All	NDPs: 0 Tests: 2	X			X					
GRO by GC-FID (W)	All	NDPs: 0 Tests: 2			X			X			
Low Level Hexavalent Chromium (w)	All	NDPs: 0 Tests: 2		X			X				
Mercury Unfiltered	All	NDPs: 0 Tests: 2		X			X				
PAH Spec MS - Aqueous (W)	All	NDPs: 0 Tests: 2	X			X					
Total Metals by ICP-MS	All	NDPs: 0 Tests: 2		X			X				
TPH CWG (W)	All	NDPs: 0 Tests: 2	X			X					
VOC MS (W)	All	NDPs: 0 Tests: 2			X			X			

Validated

CERTIFICATE OF ANALYSIS

SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH2				
			Depth (m)	0.00 - 0.00	0.00 - 0.00				
			Sample Type	Ground Water (GW)	Ground Water (GW)				
			Date Sampled	25/09/2018	25/09/2018				
			Sampled Time	.	.				
			Date Received	29/09/2018	29/09/2018				
			SDG Ref	180929-31	180929-31				
			Lab Sample No.(s)	18427836	18427842				
			AGS Reference	EW	EW				
Arsenic (tot.unfilt)	<2 µg/l	TM152		8.67 2 #	15.1 2 #				
Cadmium (tot.unfilt)	<0.5 µg/l	TM152		0.512 2 #	1.14 2 #				
Chromium (tot.unfilt)	<3 µg/l	TM152		30.4 2 #	79.1 2 #				
Copper (tot.unfilt)	<1 µg/l	TM152		24.6 2 #	69 2 #				
Lead (tot.unfilt)	<1 µg/l	TM152		13.5 2 #	38.7 2 #				
Nickel (tot.unfilt)	<1 µg/l	TM152		52.2 2 #	104 2 #				
Selenium (tot.unfilt)	<1 µg/l	TM152		2.96 2 #	5.38 2 #				
Zinc (tot.unfilt)	<5 µg/l	TM152		134 2 #	177 2 #				
Mercury (tot.unfilt)	<0.02 µg/l	TM183		<0.02 2 #	0.101 2 #				
Sulphate	<2000 µg/l	TM184		71500 #	251000 #				
Low Level Hexavalent Chromium	<3 µg/l	TM331		<3	<3				

CERTIFICATE OF ANALYSIS

SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

PAH Spec MS - Aqueous (W)

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH2				
			Depth (m)	0.00 - 0.00	0.00 - 0.00				
			Sample Type	Ground Water (GW)	Ground Water (GW)				
			Date Sampled	25/09/2018	25/09/2018				
			Sampled Time	.	.				
			Date Received	29/09/2018	29/09/2018				
			SDG Ref	180929-31	180929-31				
			Lab Sample No.(s)	18427836	18427842				
			AGS Reference	EW	EW				
Naphthalene (aq)	<0.01 µg/l	TM178		<0.01	<0.01				
Acenaphthene (aq)	<0.005 µg/l	TM178		<0.005	<0.005				
Acenaphthylene (aq)	<0.005 µg/l	TM178		<0.005	<0.005				
Fluoranthene (aq)	<0.005 µg/l	TM178		<0.005	0.0268				
Anthracene (aq)	<0.005 µg/l	TM178		<0.005	<0.005				
Phenanthrene (aq)	<0.005 µg/l	TM178		<0.005	<0.005				
Fluorene (aq)	<0.005 µg/l	TM178		<0.005	<0.005				
Chrysene (aq)	<0.005 µg/l	TM178		<0.005	<0.005				
Pyrene (aq)	<0.005 µg/l	TM178		<0.005	0.0353				
Benzo(a)anthracene (aq)	<0.005 µg/l	TM178		<0.005	<0.005				
Benzo(b)fluoranthene (aq)	<0.005 µg/l	TM178		<0.005	<0.005				
Benzo(k)fluoranthene (aq)	<0.005 µg/l	TM178		<0.005	<0.005				
Benzo(a)pyrene (aq)	<0.002 µg/l	TM178		<0.002	<0.002				
Dibenzo(a,h)anthracene (aq)	<0.005 µg/l	TM178		<0.005	<0.005				
Benzo(g,h,i)perylene (aq)	<0.005 µg/l	TM178		<0.005	<0.005				
Indeno(1,2,3-cd)pyrene (aq)	<0.005 µg/l	TM178		<0.005	<0.005				
PAH, Total Detected USEPA 16 (aq)	<0.082 µg/l	TM178		<0.082	<0.082				

CERTIFICATE OF ANALYSIS

SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

TPH CWG (W)

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH2				
			Depth (m)	0.00 - 0.00	0.00 - 0.00				
			Sample Type	Ground Water (GW)	Ground Water (GW)				
			Date Sampled	25/09/2018	25/09/2018				
			Sampled Time	.	.				
			Date Received	29/09/2018	29/09/2018				
			SDG Ref	180929-31	180929-31				
			Lab Sample No.(s)	18427836	18427842				
			AGS Reference	EW	EW				
GRO Surrogate % recovery**	%	TM245		101	101				
GRO >C5-C12	<50 µg/l	TM245		<50 #	<50 #				
Aliphatics >C5-C6	<10 µg/l	TM245		<10	<10				
Aliphatics >C6-C8	<10 µg/l	TM245		<10	<10				
Aliphatics >C8-C10	<10 µg/l	TM245		<10	<10				
Aliphatics >C10-C12	<10 µg/l	TM245		<10	<10				
Aliphatics >C12-C16 (aq)	<10 µg/l	TM174		<10	<10				
Aliphatics >C16-C21 (aq)	<10 µg/l	TM174		<10	<10				
Aliphatics >C21-C35 (aq)	<10 µg/l	TM174		<10	34				
Total Aliphatics >C12-C35 (aq)	<10 µg/l	TM174		<10	34				
Aromatics >EC5-EC7	<10 µg/l	TM245		<10	<10				
Aromatics >EC7-EC8	<10 µg/l	TM245		<10	<10				
Aromatics >EC8-EC10	<10 µg/l	TM245		<10	<10				
Aromatics >EC10-EC12	<10 µg/l	TM245		<10	<10				
Aromatics >EC12-EC16 (aq)	<10 µg/l	TM174		<10	<10				
Aromatics >EC16-EC21 (aq)	<10 µg/l	TM174		<10	<10				
Aromatics >EC21-EC35 (aq)	<10 µg/l	TM174		<10	<10				
Total Aromatics >EC12-EC35 (aq)	<10 µg/l	TM174		<10	<10				
Total Aliphatics & Aromatics >C5-35 (aq)	<10 µg/l	TM174		<10	34				
Aliphatics >C16-C35 Aqueous	<10 µg/l	TM174		<10	34				
Aromatics >EC16-EC35 (aq)	<10 µg/l	TM174		<10	<10				

CERTIFICATE OF ANALYSIS

SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

VOC MS (W)

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH2			
			Depth (m)	0.00 - 0.00	0.00 - 0.00			
			Sample Type	Ground Water (GW)	Ground Water (GW)			
			Date Sampled	25/09/2018	25/09/2018			
			Sampled Time	.	.			
			Date Received	29/09/2018	29/09/2018			
			SDG Ref	180929-31	180929-31			
			Lab Sample No.(s)	18427836	18427842			
			AGS Reference	EW	EW			
Methyl tertiary butyl ether (MTBE)	<1 µg/l	TM208		<1 #	<1 #			
Benzene	<1 µg/l	TM208		<1 #	<1 #			
Toluene	<1 µg/l	TM208		<1 #	<1 #			
Ethylbenzene	<1 µg/l	TM208		<1 #	<1 #			
m,p-Xylene	<1 µg/l	TM208		<1 #	<1 #			
o-Xylene	<1 µg/l	TM208		<1 #	<1 #			
tert-Amyl methyl ether (TAME)	<1 µg/l	TM208		<1 #	<1 #			
Sum of detected Xylenes	<2 µg/l	TM208		<2	<2			

CERTIFICATE OF ANALYSIS

SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

Table of Results - Appendix

Method No	Reference	Description
TM061	Method for the Determination of EPH,Massachusetts Dept.of EP, 1998	Determination of Extractable Petroleum Hydrocarbons by GC-FID (C10-C40)
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS
TM174	Analysis of Petroleum Hydrocarbons in Environmental Media – Total Petroleum Hydrocarbon Criteria	Determination of Speciated Extractable Petroleum Hydrocarbons in Waters by GC-FID
TM178	Modified: US EPA Method 8100	Determination of Polynuclear Aromatic Hydrocarbons (PAH) by GC-MS in Waters
TM183	BS EN 23506:2002, (BS 6068-2.74:2002) ISBN 0 580 38924 3	Determination of Trace Level Mercury in Waters and Leachates by PSA Cold Vapour Atomic Fluorescence Spectrometry
TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers
TM208	Modified: US EPA Method 8260b & 624	Determination of Volatile Organic Compounds by Headspace / GC-MS in Waters
TM245	By GC-FID	Determination of GRO by Headspace in waters
TM331		Low Level Hexavalent Chromium

NA = not applicable.

Chemical testing (unless subcontracted) performed at ALS Environmental Hawarden (Method codes TM) or ALS Environmental Aberdeen (Method codes S).

CERTIFICATE OF ANALYSIS

SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

Test Completion Dates

Lab Sample No(s)	18427836	18427842
Customer Sample Ref.	BH1	BH2
AGS Ref.	EW	EW
Depth	0.00 - 0.00	0.00 - 0.00
Type	Ground Water	Ground Water
Anions by Kone (w)	04-Oct-2018	04-Oct-2018
EPH CWG (Aliphatic) Aqueous GC (W)	02-Oct-2018	02-Oct-2018
EPH CWG (Aromatic) Aqueous GC (W)	02-Oct-2018	02-Oct-2018
GRO by GC-FID (W)	02-Oct-2018	30-Sep-2018
Low Level Hexavalent Chromium (w)	04-Oct-2018	04-Oct-2018
Mercury Unfiltered	02-Oct-2018	02-Oct-2018
PAH Spec MS - Aqueous (W)	01-Oct-2018	01-Oct-2018
Total Metals by ICP-MS	05-Oct-2018	02-Oct-2018
TPH CWG (W)	02-Oct-2018	02-Oct-2018
VOC MS (W)	02-Oct-2018	01-Oct-2018

CERTIFICATE OF ANALYSIS

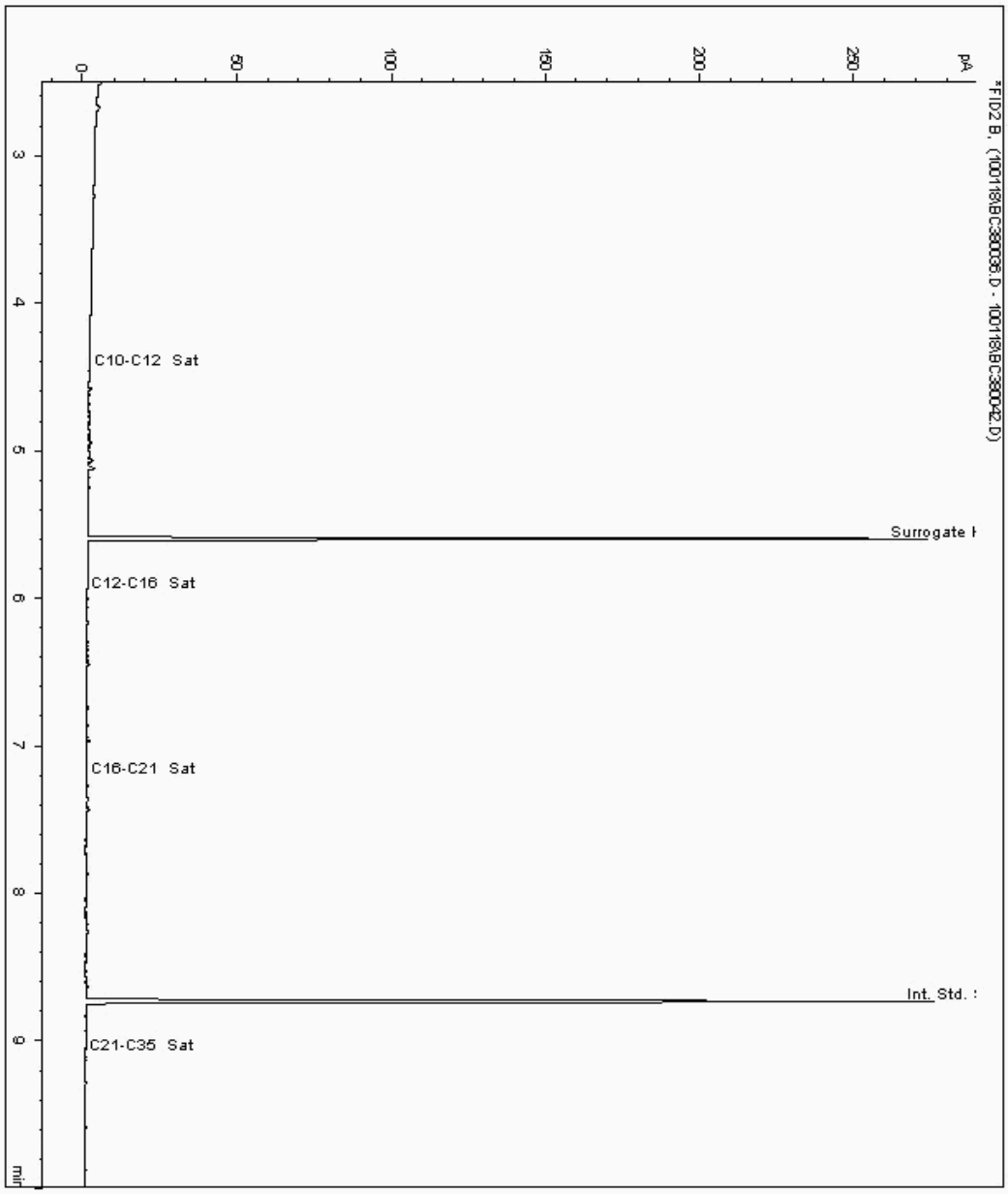
SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

Chromatogram

Analysis: EPH CWG (Aliphatic) Aqueous GC (W) **Sample No :** 18431549 **Sample ID :** BH1 **Depth :** 0.00 - 0.00

Speciated TPH - SATS (C12 - C40)

Sample Identity: 17309295-
Date Acquired : 02/10/18 02:21:37 PM
Units : ppb
Dilution :
CF : 1
Multiplier : 0.025



CERTIFICATE OF ANALYSIS

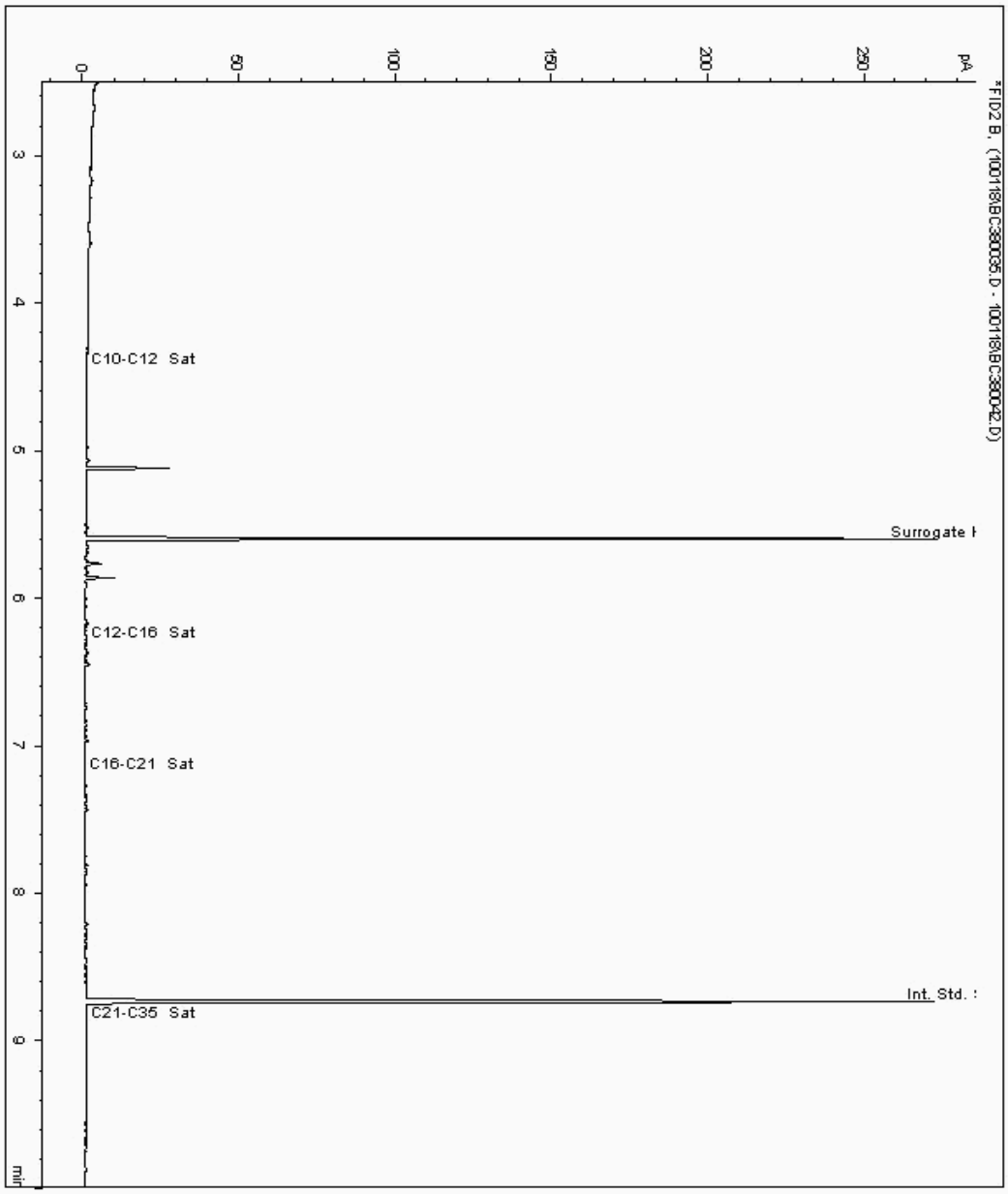
SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

Chromatogram

Analysis: EPH CWG (Aliphatic) Aqueous GC (W) **Sample No :** 18431550 **Sample ID :** BH2 **Depth :** 0.00 - 0.00

Speciated TPH - SATS (C12 - C40)

Sample Identity: 17309318-
Date Acquired : 02/10/18 01:58:28 PM
Units : ppb
Dilution :
CF : 1
Multiplier : 0.025



CERTIFICATE OF ANALYSIS

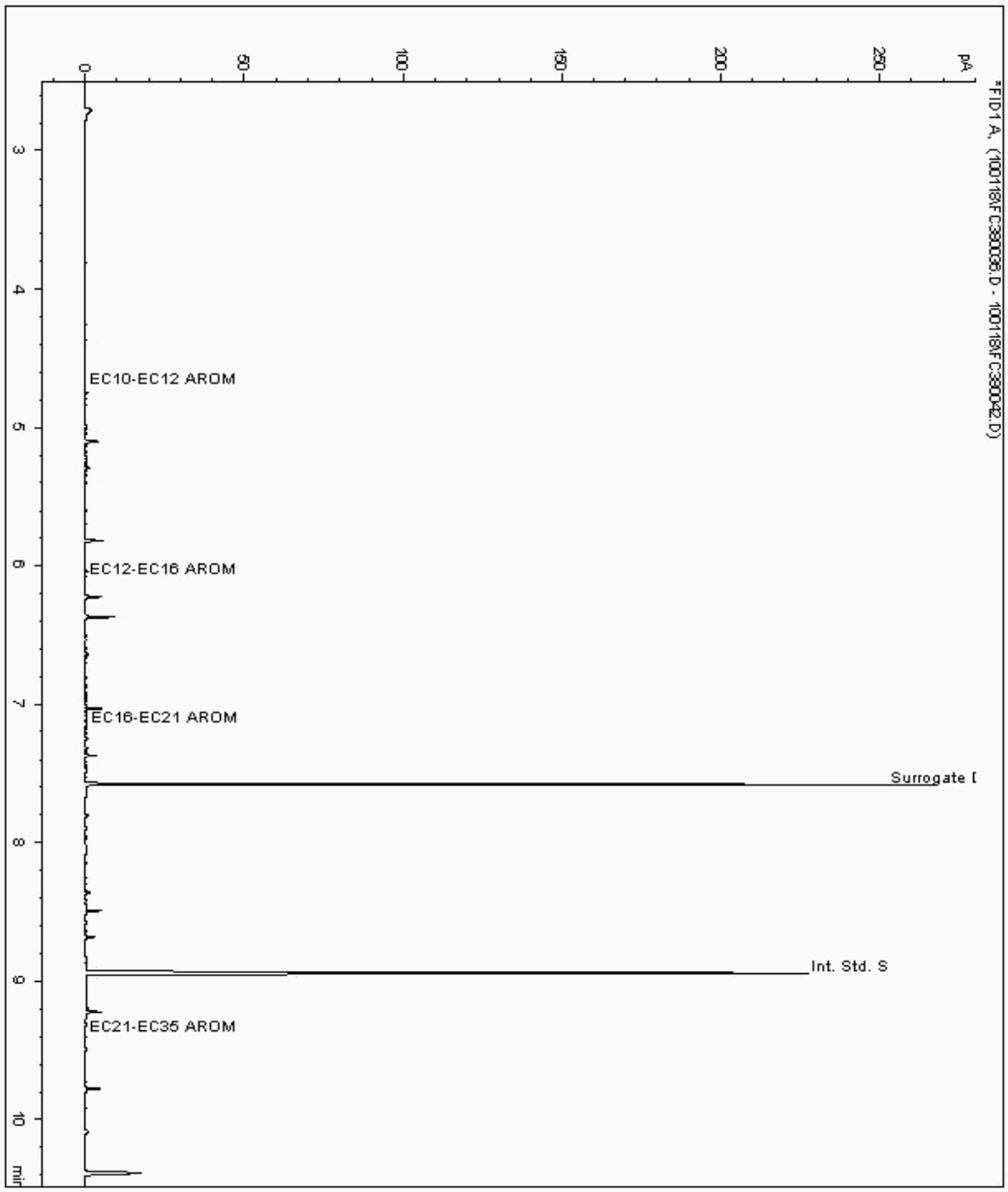
SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

Chromatogram

Analysis: EPH CWG (Aromatic) Aqueous GC (W) **Sample No :** 18431549 **Sample ID :** BH1 **Depth :** 0.00 - 0.00

Speciated TPH - AROM (C12 - C40)

Sample Identity: 17309296-
Date Acquired : 02/10/18 02:21:37 PM
Units : ppb
Dilution :
CF : 1
Multiplier : 0.025



CERTIFICATE OF ANALYSIS

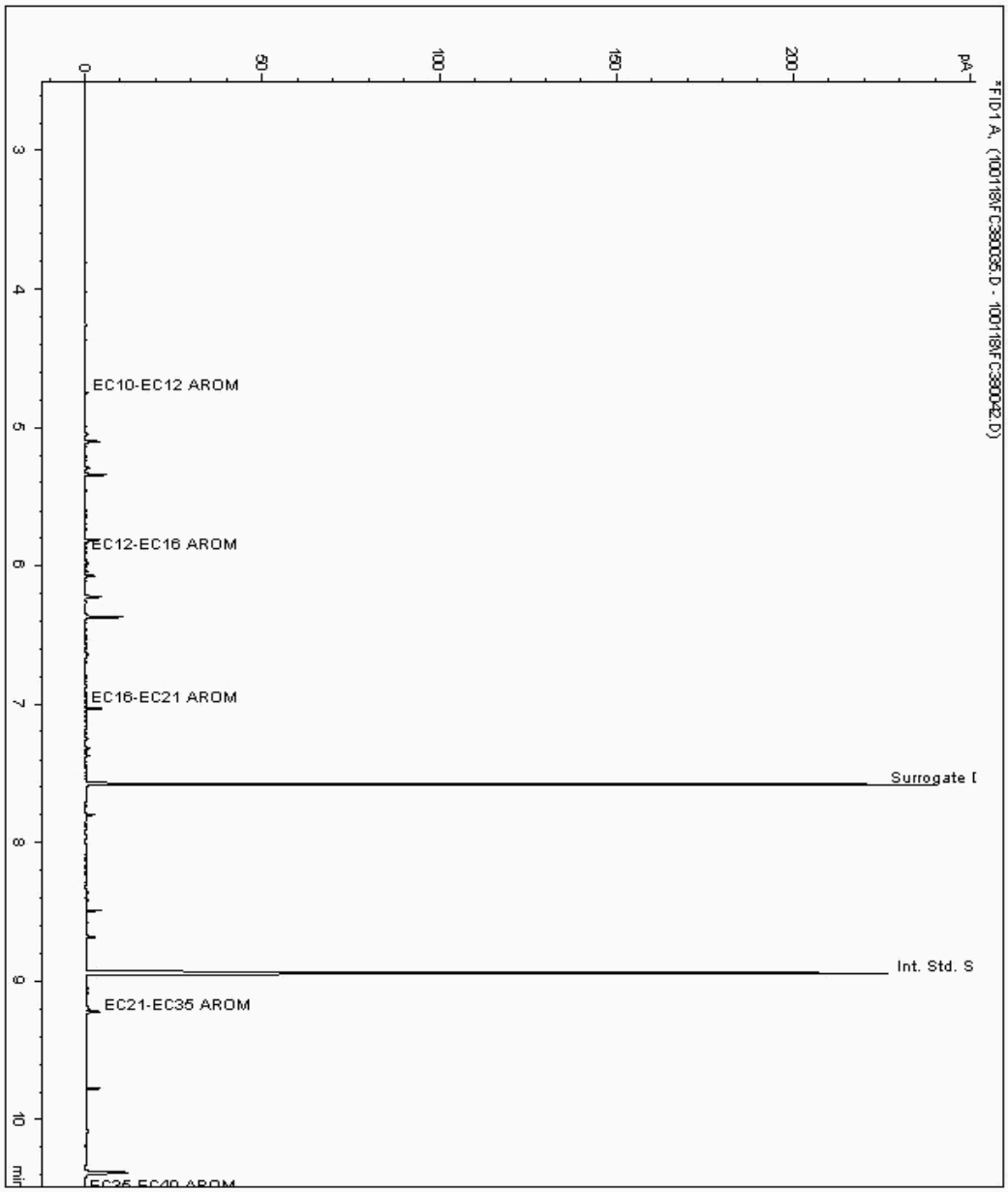
SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

Chromatogram

Analysis: EPH CWG (Aromatic) Aqueous GC (W) **Sample No :** 18431550 **Sample ID :** BH2 **Depth :** 0.00 - 0.00

Speciated TPH - AROM (C12 - C40)

Sample Identity: 17309319-
Date Acquired : 02/10/18 01:58:29 PM
Units : ppb
Dilution :
CF : 1
Multiplier : 0.025



CERTIFICATE OF ANALYSIS

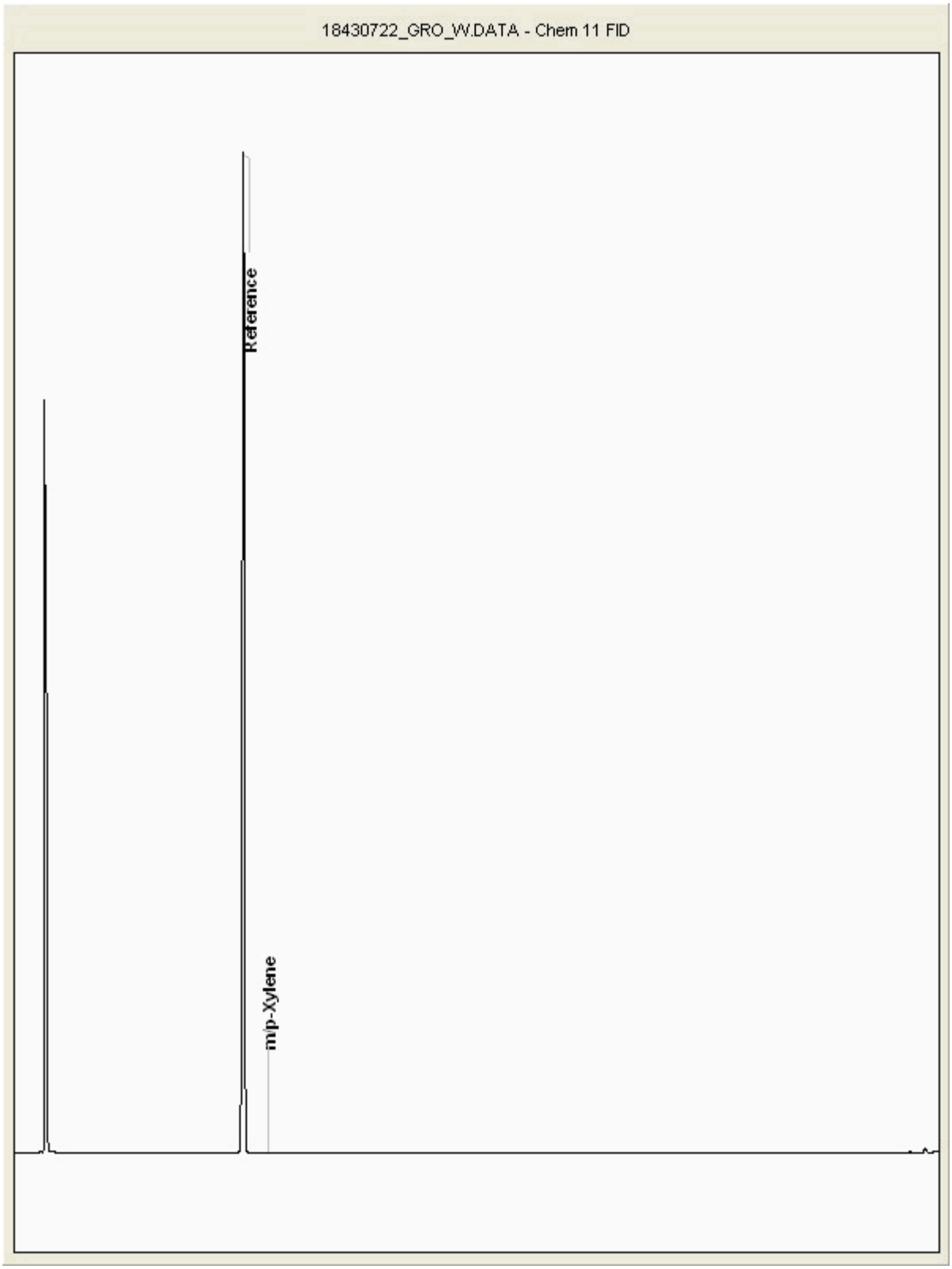
SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

Chromatogram

Analysis: GRO by GC-FID (W)

Sample No : 18430722
Sample ID : BH2

Depth : 0.00 - 0.00



CERTIFICATE OF ANALYSIS

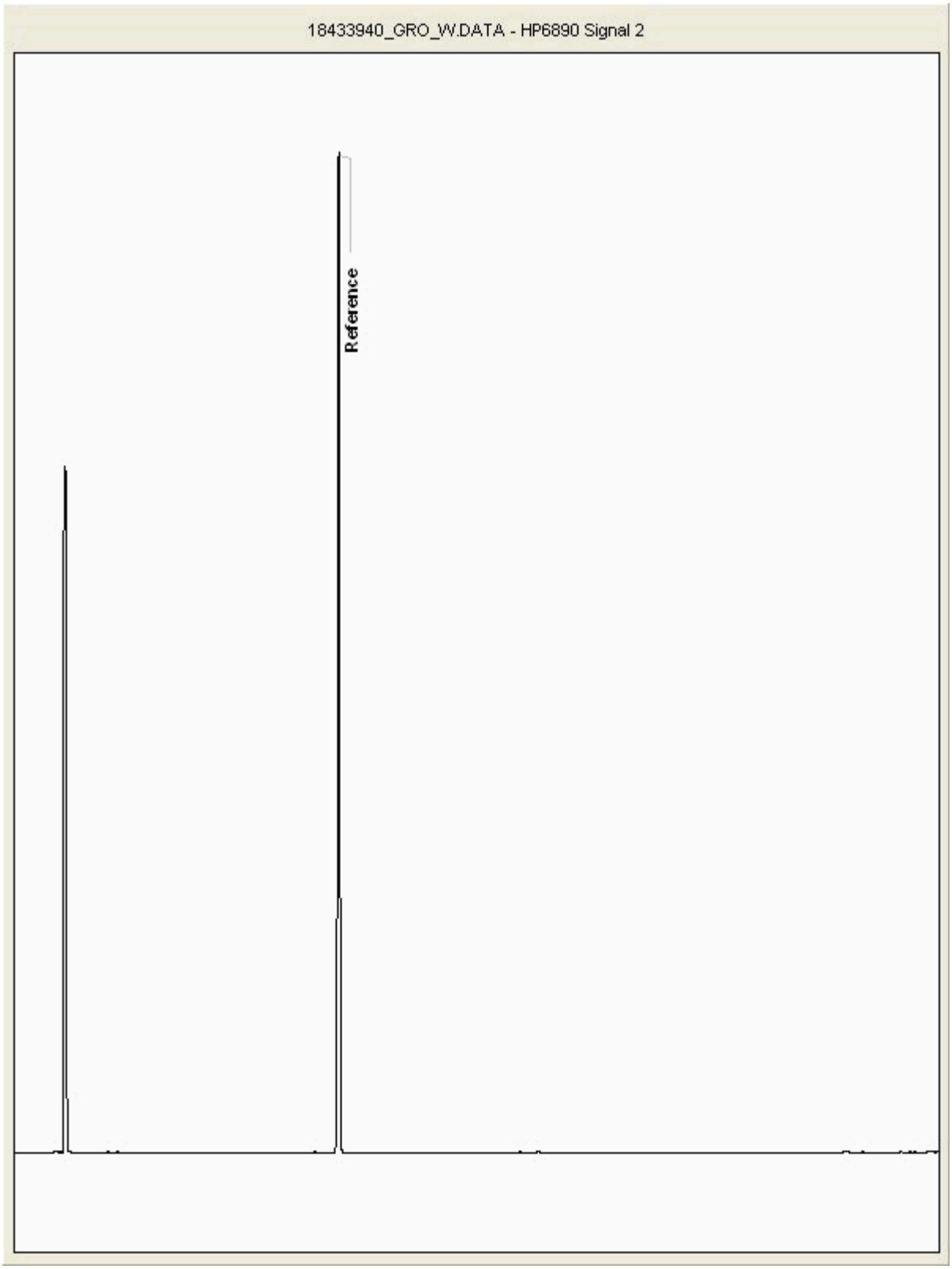
SDG:	180929-31	**Client Reference:**	MRI	**Report Number:**	475525
Location:	MRI	**Order Number:**	70048625-S01	**Superseded Report:**	475282

Chromatogram

Analysis: GRO by GC-FID (W)

Sample No : 18433940
Sample ID : BH1

Depth : 0.00 - 0.00



Appendix

General

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICs and SVOC TICs.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALS reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as “Not detected”. If no asbestos fibre types are found all will be reported as “Not detected” and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible (NDP). The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP - No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals - total metals must be requested separately.

11. Results relate only to the items tested.

12. LoDs (Limit of Detection) for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** - Surrogates are added to your sample to monitor recovery of the test requested. A % recovery is reported, results are not corrected for the recovery measured. Typical recoveries for organics tests are 70-130%. Recoveries in soils are affected by organic rich or clay rich matrices. Waters can be affected by remediation fluids or high amounts of sediment. Test results are only ever reported if all of the associated quality checks pass; it is assumed that all recoveries outside of the values above are due to matrix affect.

14. **Product analyses** - Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For leachate preparations other than Zero Headspace Extraction (ZHE) volatile loss may occur.

21. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

24. **Tentatively Identified Compounds (TICs)** are non-target peaks in VOC and SVOC analysis. All non-target peaks detected with a concentration above the LoD are subjected to a mass spectral library search. Non-target peaks with a library search confidence of >75% are reported based on the best mass spectral library match. When a non-target peak with a library search confidence of <75% is detected it is reported as “mixed hydrocarbons”. Non-target compounds identified from the scan data are semi-quantified relative to one of the deuterated internal standards, under the same chromatographic conditions as the target compounds. This result is reported as a semi-quantitative value and reported as Tentatively Identified Compounds (TICs). TICs are outside the scope of UKAS accreditation and are not moisture corrected.

Sample Deviations

If a sample is classed as deviated then the associated results may be compromised.

1	**Container with Headspace provided for volatiles analysis**
2	**Incorrect container received**
3	**Deviation from method**
4	**Holding time exceeded before sample received**
5	**Samples exceeded holding time before presevation was performed**
§	**Sampled on date not provided**
♦	**Sample holding time exceeded in laboratory**
@	**Sample holding time exceeded due to sampled on date**
&	**Sample Holding Time exceeded - Late arrival of instructions.**

Asbestos

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than: - Trace - Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

Appendix D.2

GEOTECHNICAL TESTING

Unit 7-8 Hawarden Business Park
Manor Road (off Manor Lane)
Hawarden
Deeside
CH5 3US
Tel: (01244) 528700
Fax: (01244) 528701
email: hawardencustomerservices@alsglobal.com
Website: www.alsenvironmental.co.uk

WSP PB MLN
The Victoria
150-182 The Quays
Salford
Manchester
Lancashire
M50 3SP

Attention: Emily Morgan

CERTIFICATE OF ANALYSIS

Date:	06 October 2018
Customer:	H_WSP_MAN
Sample Delivery Group (SDG):	180903-56
Your Reference:	MRI - Porject RED
Location:	Manchester Royal Infirmary
Report No:	475549

This report has been revised and directly supersedes 474901 in its entirety.

We received 11 samples on Monday September 03, 2018 and 11 of these samples were scheduled for analysis which was completed on Saturday October 06, 2018. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

Chemical testing (unless subcontracted) performed at ALS Life Sciences Ltd Hawarden (Method codes TM) or ALS Life Sciences Ltd Aberdeen (Method codes S).

Approved By:

Sonia McWhan

Operations Manager

ALS Life Sciences Limited. Registered Office: Units 7 & 8 Hawarden Business Park, Manor Road, Hawarden, Deeside, CH5 3US. Registered in England and Wales No. 4057291.

CERTIFICATE OF ANALYSIS

SDG:	180903-56	**Client Reference:**	MRI - Porject RED	**Report Number:**	475549
Location:	Manchester Royal Infirmary	**Order Number:**	70048625-S01	**Superseded Report:**	474901

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
18246263	BH1	CORE	12.00 - 15.80	24/08/2018
18246259	BH1	U	2.50 - 2.95	21/08/2018
18246266	BH1	U	3.60 - 4.05	22/08/2018
18246268	BH1	U	4.70 - 5.15	22/08/2018
18246272	BH1	U	6.70 - 7.15	23/08/2018
18246274	BH1	U	8.60 - 9.05	23/08/2018
18246261	BH1	SPT	9.97 - 10.35	22/08/2018
18246276	BH2	U	2.00 - 2.45	28/08/2018
18246278	BH2	U	3.30 - 3.75	29/08/2018
18246280	BH2	U	4.45 - 4.90	29/08/2018
18246282	BH2	U	6.35 - 6.80	29/08/2018

Maximum Sample/Coolbox Temperature (°C) :

ISO5667-3 Water quality - Sampling - Part3 -
During Transportation samples shall be stored in a cooling device capable of maintaining a temperature of (5±3)°C.

ALS have data which show that a cool box with 4 frozen icepacks is capable of maintaining pre-chilled samples at a temperature of (5±3)°C for a period of up to 24hrs.

Only received samples which have had analysis scheduled will be shown on the following pages.

Validated

CERTIFICATE OF ANALYSIS

SDG:	180903-56	**Client Reference:**	MRI - Porject RED	**Report Number:**	475549
Location:	Manchester Royal Infirmary	**Order Number:**	70048625-S01	**Superseded Report:**	474901

Results Legend

X **Test**

N **No Determination Possible**

Sample Types -
S - Soil/Solid
UNS - Unspecified Solid
GW - Ground Water
SW - Surface Water
LE - Land Leachate
PL - Prepared Leachate
PR - Process Water
SA - Saline Water
TE - Trade Effluent
TS - Treated Sewage
US - Untreated Sewage
RE - Recreational Water
DW - Drinking Water Non-regulatory
UNL - Unspecified Liquid
SL - Sludge
G - Gas
OTH - Other

Lab Sample No(s)	18246263	18246259	18246266	18246268	18246272	18246274	18246261	18246276	18246278	18246280	18246282			
Customer Sample Reference	BH1	BH1	BH1	BH1	BH1	BH1	BH1	BH2	BH2	BH2	BH2			
AGS Reference	CORE	U	U	U	U	U	SPT	U	U	U	U			
Depth (m)	12.00 - 15.80	2.50 - 2.95	3.60 - 4.05	4.70 - 5.15	6.70 - 7.15	8.60 - 9.05	9.97 - 10.35	2.00 - 2.45	3.30 - 3.75	4.45 - 4.90	6.35 - 6.80			
Container	Geolabs container	Geolabs container	Geolabs container	Geolabs container	Geolabs container	BAG	Geolabs container	Geolabs container	Geolabs container	Geolabs container	Geolabs container	BAG	Geolabs container	
Sample Type	S	S	S	S	S	S	S	S	S	S	S	S	S	
Anions by Kone (soil)	All	NDPs: 0 Tests: 2						X					X	
Geotechnical Testing*	All	NDPs: 1 Tests: 11	N											
			X	X	X	X	X		X	X	X	X	X	X
pH	All	NDPs: 0 Tests: 2						X					X	

Validated

CERTIFICATE OF ANALYSIS

SDG:	180903-56	**Client Reference:**	MRI - Porject RED	**Report Number:**	475549
Location:	Manchester Royal Infirmary	**Order Number:**	70048625-S01	**Superseded Report:**	474901

Results Legend	
#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	Depth (m)	Sample Type	Date Sampled	Sample Time	Date Received	SDG Ref	Lab Sample No.(s)	AGS Reference
			BH1	12.00 - 15.80	GeoTech Soils	24/08/2018	.	03/09/2018	180903-56	18246263	CORE
			BH1	2.50 - 2.95	GeoTech Soils	21/08/2018	.	03/09/2018	180903-56	18246259	U
			BH1	3.60 - 4.05	GeoTech Soils	22/08/2018	.	03/09/2018	180903-56	18246266	U
			BH1	4.70 - 5.15	GeoTech Soils	22/08/2018	.	03/09/2018	180903-56	18246268	U
			BH1	6.70 - 7.15	GeoTech Soils	23/08/2018	.	03/09/2018	180903-56	18246272	U
			BH1	8.60 - 9.05	GeoTech Soils	23/08/2018	.	03/09/2018	180903-56	18246274	U
Moisture Content Ratio (% of as received sample)	%	PM024									1.5
Moisture Content (GEOTECH)*		SUB		See Attached	See Attached	See Attached	See Attached	See Attached	See Attached	See Attached	See Attached
Plasticity Index 4 point*		SUB		See Attached	See Attached	See Attached		See Attached	See Attached	See Attached	See Attached
Point Load Diametral*		SUB	See Attached								
Point Load Axial*		SUB	See Attached								
Triaxial U100 Single*		SUB		See Attached	See Attached	See Attached		See Attached	See Attached	See Attached	See Attached
pH	1 pH Units	TM133									8.72 @
Water Soluble Sulphate as SO4 2:1 Extract	<0.004 g/l	TM243									0.0499 @

Validated

CERTIFICATE OF ANALYSIS

SDG:	180903-56	**Client Reference:**	MRI - Porject RED	**Report Number:**	475549
Location:	Manchester Royal Infirmary	**Order Number:**	70048625-S01	**Superseded Report:**	474901

Results Legend	
#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	BH1	BH2	BH2	BH2	BH2
			Depth (m)	9.97 - 10.35	2.00 - 2.45	3.30 - 3.75	4.45 - 4.90	6.35 - 6.80
			Sample Type	GeoTech Soils	GeoTech Soils	GeoTech Soils	GeoTech Soils	GeoTech Soils
			Date Sampled	22/08/2018	28/08/2018	29/08/2018	29/08/2018	29/08/2018
			Sample Time	.	.	.	.	.
			Date Received	03/09/2018	03/09/2018	03/09/2018	03/09/2018	03/09/2018
			SDG Ref	180903-56	180903-56	180903-56	180903-56	180903-56
			Lab Sample No.(s)	18246261	18246276	18246278	18246280	18246282
			AGS Reference	SPT	U	U	U	U
Moisture Content Ratio (% of as received sample)	%	PM024						5.3
Moisture Content (GEOTECH)*		SUB		See Attached	See Attached	See Attached	See Attached	See Attached
Plasticity Index 4 point*		SUB		See Attached	See Attached	See Attached	See Attached	See Attached
Triaxial U100 Single*		SUB			See Attached	See Attached	See Attached	See Attached
pH	1 pH Units	TM133						8.87 @
Water Soluble Sulphate as SO4 2:1 Extract	<0.004 g/l	TM243						0.0401 @

Validated

CERTIFICATE OF ANALYSIS

SDG:	180903-56	**Client Reference:**	MRI - Porject RED	**Report Number:**	475549
Location:	Manchester Royal Infirmary	**Order Number:**	70048625-S01	**Superseded Report:**	474901

Notification of NDPs (No determination possible)

Date Received : 03/09/2018 16:54:52

Sample No	Customer Sample Ref.	Depth (m)	Test	Comment
18246263	BH1 COREZ	12.00 - 15.80	Geotechnical Testing*	See Comments for cancellation details

CERTIFICATE OF ANALYSIS

SDG:	180903-56	**Client Reference:**	MRI - Porject RED	**Report Number:**	475549
Location:	Manchester Royal Infirmary	**Order Number:**	70048625-S01	**Superseded Report:**	474901

Table of Results - Appendix

Method No	Reference	Description
PM024	Modified BS 1377	Soil preparation including homogenisation, moisture screens of soils for Asbestos Containing Material
SUB		Subcontracted Test
TM133	BS 1377: Part 3 1990;BS 6068-2.5	Determination of pH in Soil and Water using the GLpH pH Meter
TM243		Mixed Anions In Soils By Kone

NA = not applicable.

Chemical testing (unless subcontracted) performed at ALS Life Sciences Ltd Hawarden (Method codes TM) or ALS Life Sciences Ltd Aberdeen (Method codes S).

Validated

CERTIFICATE OF ANALYSIS

SDG:	180903-56	**Client Reference:**	MRI - Porject RED	**Report Number:**	475549
Location:	Manchester Royal Infirmary	**Order Number:**	70048625-S01	**Superseded Report:**	474901

Test Completion Dates

Lab Sample No(s)	18246259	18246261	18246263	18246266	18246268	18246272	18246274	18246276	18246278	18246280
Customer Sample Ref.	BH1	BH1	BH1	BH1	BH1	BH1	BH1	BH2	BH2	BH2
AGS Ref.	U	SPT	CORE	U	U	U	U	U	U	U
Depth	2.50 - 2.95	9.97 - 10.35	12.00 - 15.80	3.60 - 4.05	4.70 - 5.15	6.70 - 7.15	8.60 - 9.05	2.00 - 2.45	3.30 - 3.75	4.45 - 4.90
Type	GeoTech Soils	GeoTech Soils	GeoTech Soils	GeoTech Soils	GeoTech Soils	GeoTech Soils	GeoTech Soils	GeoTech Soils	GeoTech Soils	GeoTech Soils
Anions by Kone (soil)							06-Oct-2018			
Geotechnical Testing*	25-Sep-2018	28-Sep-2018	25-Sep-2018	25-Sep-2018	25-Sep-2018	28-Sep-2018	02-Oct-2018	25-Sep-2018	25-Sep-2018	25-Sep-2018
pH							04-Oct-2018			

Lab Sample No(s)	18246282
Customer Sample Ref.	BH2
AGS Ref.	U
Depth	6.35 - 6.80
Type	GeoTech Soils
Anions by Kone (soil)	06-Oct-2018
Geotechnical Testing*	02-Oct-2018
pH	04-Oct-2018

2718

ALS Environmental
Units 7-8 Hawarden Business Park
Manor Lane
Hawarden
Deeside
CH5 3US

For the attention of Dave Jones/Annabella Szelyes

Version No. 1
Page No. 1 of 5
Date of Issue 21/09/2018

TEST REPORT

PROJECT/SITE	Manchester Royal Infirmary	Samples received	05/09/2018
GEL REPORT NUMBER	34606	Schedule received	05/09/2018
Your ref/PO:	180903-56	Testing commenced	11/09/2018
Test report refers to	Schedule 1	Status	Final

SUMMARY OF RESULTS ATTACHED

TEST METHOD & DESCRIPTION	QUANTITY	ACCREDITED TEST
BS EN ISO 17892-1: 2014:5. Water Content	10	YES
BS1377: Part 2: 1990:4.2-4.4&5.2-5.4, Liquid & Plastic Limits	9	YES
BS1377: Part 7: 1990:8&9, Undrained Triaxial Compression	8	YES
ISRM: 2007: Point Load Strength Test	1	YES

Remarks
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Approved Signatories:
W Jones (Lab Manager) E Crimp (Technical Manager)
J Hanson (Director) N Parry (Director)

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LIQUID AND PLASTIC LIMITS

BS.1377 : PART 2 : 1990 : 4 and 5

CLIENT ALS ENVIRONMENTAL

SITE MANCHESTER ROYAL INFIRMARY

borehole /trial pit no.	sample no./type	sample depth (m)	specimen depth (m)	natural water content (%)	specimen preparation and test method	fraction >0.425 mm (%)	liquid limit (%)	plastic limit (%)	plasticity index (%)	description and remarks
BH1	U	2.50	2.70	18.6	BXE	9	42	18	24	Brown mottled bluish grey slightly gravelly slightly sandy silty CLAY
BH1	U	3.60	3.80	14.3	BXE	19	33	15	18	Brown slightly gravelly slightly sandy CLAY
BH1	U	4.70	4.85	12.3	BXE	13	31	15	16	Brown slightly gravelly slightly sandy silty CLAY
BH1	U	6.70	6.80	15.2	E					Brown slightly gravelly slightly sandy CLAY
BH1	U	8.60	8.80	10.9	BXE	11	32	15	17	Brown slightly gravelly slightly sandy CLAY
BH1	SPTLS	9.97	9.97	9.4	BYE	57	22	16	6	Brown very clayey very sandy GRAVEL
BH2	U	2.00	2.20	10.4	BXE	3	48	22	26	Brown slightly gravelly slightly sandy silty CLAY
BH2	U	3.30	3.50	12.4	BXE	16	33	16	17	Brown slightly gravelly slightly sandy CLAY
BH2	U	4.45	4.70	12.5	BXE	16	28	14	14	Brown slightly gravelly slightly sandy silty CLAY
BH2	U	6.35	6.58	14.7	BXE	13	29	15	14	Brown slightly gravelly slightly sandy CLAY

general remarks

natural water content determined in accordance with BS EN ISO 17892 - 1 : 2014 (unless specified)

NP denotes non plastic

# denotes sample tested is smaller than that which is recommended in accordance with BS1377 or BS EN ISO 17892

specimen preparation		test method	CONTRACT	CHECKED
A - as received	D - oven dried (60°C)	X - cone penetrometer (test 4.3)		
B - washed on 0.425mm sieve	E - oven dried (105°C)	Y - cone penetrometer (test 4.4)	**34606**	**TB**
C - air dried	F - not known	Z - casagrande apparatus (test 4.5)		

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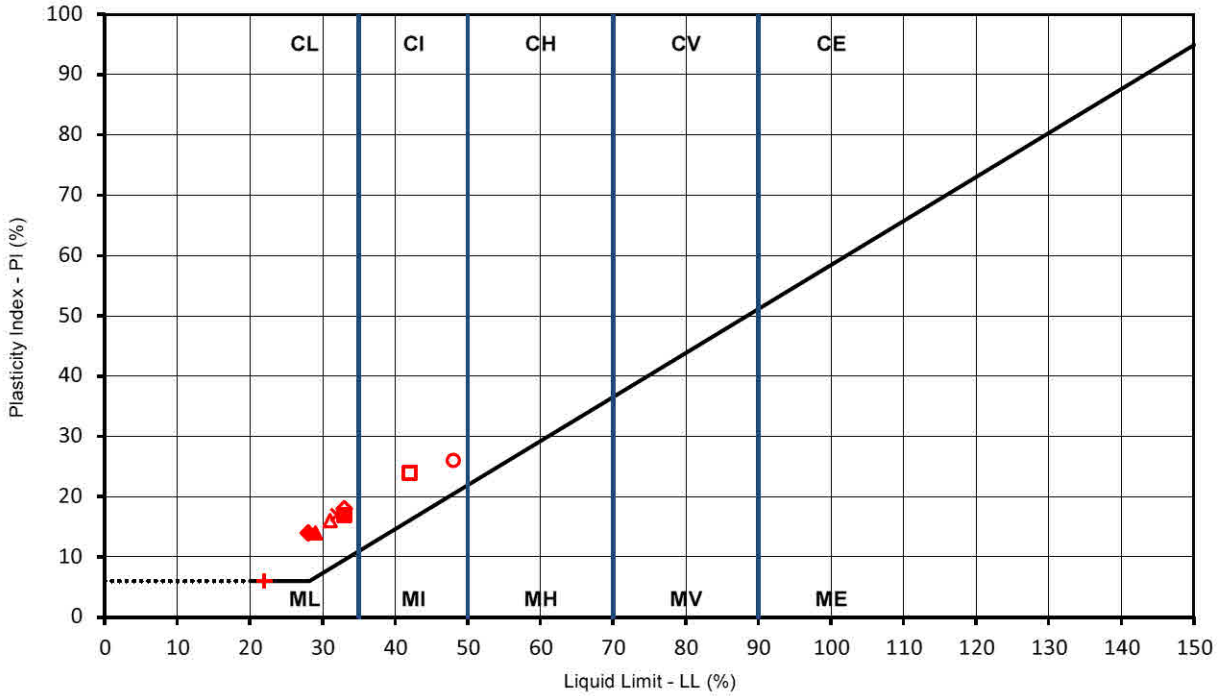
ATTERBERG LINE PLOT

CLIENT ALS ENVIRONMENTAL

SITE MANCHESTER ROYAL INFIRMARY



	BH/TP No.	depth (m)	LL	PL	PI	remarks
□	BH1	2.70	42	18	24	
◇	BH1	3.80	33	15	18	
△	BH1	4.85	31	15	16	
×	BH1	8.80	32	15	17	
+	BH1	9.97	22	16	6	
○	BH2	2.20	48	22	26	
■	BH2	3.50	33	16	17	
◆	BH2	4.70	28	14	14	
▲	BH2	6.58	29	15	14	

CONTRACT	CHECKED
34606	TB

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UNDRAINED TRIAXIAL COMPRESSION

BS.1377 : PART 7 : 1990 : 8

CLIENT ALS ENVIRONMENTAL

SITE MANCHESTER ROYAL INFIRMARY

borehole /trial pit no.	sample		specimen depth	code	moisture content		dimensions		density		cell pressure	rate of strain	deviator stress	failure strain	failure mode	shear strength*	description and remarks
	no./type	depth (m)	(m)		initial (%)	final (%)	length (mm)	diameter (mm)	bulk (Mg/m^3)	dry (Mg/m^3)	(kPa)	(%/min)	(kPa)	(%)		(kPa)	
BH1	U	2.50	2.50	UU100	21.2	20.7	206	104	2.09	1.73	50	2.0	278	11.7	S	139	Brown mottled bluish grey slightly gravelly slightly sandy silty CLAY
BH1	U	3.60	3.60	UU100	14.2	14.0	206	104	2.20	1.93	70	2.0	255	12.1	I	127	Brown slightly gravelly slightly sandy CLAY
BH1	U	4.70	4.90	UU100	12.8	13.0	192	104	2.26	2.00	95	2.0	526	8.9	S	263	Brown slightly gravelly slightly sandy silty CLAY. Maximum load factor reached
BH1	U	8.60	8.85	UU100	13.3	13.2	206	104	2.25	1.99	170	2.0	498	19.4	I	249	Brown slightly gravelly slightly sandy CLAY
BH2	U	2.00	2.00	UU100	20.4	20.2	206	104	2.11	1.75	40	2.0	212	9.2	S	106	Brown slightly gravelly slightly sandy CLAY
BH2	U	3.30	3.30	UU100	12.1	12.8	206	104	2.25	2.01	65	2.0	706	12.6	S	353	Brown slightly gravelly slightly silty CLAY
BH2	U	4.45	4.50	UU100	12.0	12.4	206	104	2.27	2.03	90	2.0	370	14.6	I	185	Brown slightly gravelly slightly sandy silty CLAY
BH2	U	6.35	6.35	UU100	13.4	13.4	195	104	2.25	1.99	130	2.0	283	20.0	B	142	Brown slightly gravelly slightly sandy CLAY

general remarks:

* shear strength taken as half deviator stress at failure for each stage
membrane correction applied
sample taken vertically (unless otherwise specified)
strain rate 2%/min (unless otherwise specified)

code:

UU - unconsolidated undrained
M - multi stage
S - set of three
R - remoulded

failure mode:

B - barrel (plastic failure)
S - shear (brittle failure)
I - intermediate
O - other (see remarks)

membrane type/thickness:

latex membrane used (unless otherwise specified)
38 - 0.2mm
70 - 0.4mm
100 - 0.4mm

CONTRACT	CHECKED
34606	**TB**

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POINT LOAD STRENGTH TEST

I.S.R.M. Suggested Methods : 2007 Edition

CLIENT ALS ENVIRONMENTAL

SITE MANCHESTER ROYAL INFIRMARY

borehole /trial pit no.	sample depth (m)	test type	test orien-tation	moisture condition	width W (mm)	length L (mm)	platen sep. D (mm)	failure load P (kN)	equiv. diam. De (mm)	Is (MPa)	size factor	Is(50) (MPa)	description and remarks
BH1	14.00	D	Y	P		40	80	0.20	80.00	0.03	1.24	0.04	Purplish brown LIMESTONE
BH1	14.00	A	X	P	80		50	0.20	71.36	0.04	1.17	0.05	Purplish brown LIMESTONE

general remarks

tests carried out in accordance with I.S.R.M.(2007): Suggested Methods for Determining Point Load Strength

test machine PLM02

test type	test orientation relative to discontinuities		moisture condition	CONTRACT	CHECKED
A - axial	X - perpendicular	U - unknown	N - natural moisture content		
D - diametral	Y - parallel		P - partially air dried	**34606**	**TB**
I - irregular lump	Z - oblique		S - soaked		

Appendix

General

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICs and SVOC TICs.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALS reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as “Not detected”. If no asbestos fibre types are found all will be reported as “Not detected” and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible (NDP). The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP - No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals - total metals must be requested separately.

11. Results relate only to the items tested.

12. LoDs (Limit of Detection) for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** - Surrogates are added to your sample to monitor recovery of the test requested. A % recovery is reported, results are not corrected for the recovery measured. Typical recoveries for organics tests are 70-130%. Recoveries in soils are affected by organic rich or clay rich matrices. Waters can be affected by remediation fluids or high amounts of sediment. Test results are only ever reported if all of the associated quality checks pass; it is assumed that all recoveries outside of the values above are due to matrix affect.

14. **Product analyses** - Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For leachate preparations other than Zero Headspace Extraction (ZHE) volatile loss may occur.

21. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

24. **Tentatively Identified Compounds (TICs)** are non-target peaks in VOC and SVOC analysis. All non-target peaks detected with a concentration above the LoD are subjected to a mass spectral library search. Non-target peaks with a library search confidence of >75% are reported based on the best mass spectral library match. When a non-target peak with a library search confidence of <75% is detected it is reported as “mixed hydrocarbons”. Non-target compounds identified from the scan data are semi-quantified relative to one of the deuterated internal standards, under the same chromatographic conditions as the target compounds. This result is reported as a semi-quantitative value and reported as Tentatively Identified Compounds (TICs). TICs are outside the scope of UKAS accreditation and are not moisture corrected.

Sample Deviations

If a sample is classed as deviated then the associated results may be compromised.

1	**Container with Headspace provided for volatiles analysis**
2	**Incorrect container received**
3	**Deviation from method**
4	**Holding time exceeded before sample received**
5	**Samples exceeded holding time before presevation was performed**
§	**Sampled on date not provided**
♦	**Sample holding time exceeded in laboratory**
@	**Sample holding time exceeded due to sampled on date**
&	**Sample Holding Time exceeded - Late arrival of instructions.**

Asbestos

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than: - Trace - Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

Appendix E

GROUNDWATER & GROUND GAS

MONITORING RESULTS

Ground Gas Monitoring - Manchester Royal Infirmary

BH	Date	Flow		aP	CH4		Co2		O2		DTW	DTB
		Peak	Steady		Peak	Steady	Peak	Steady	Peak	Steady		
BH1	06/09/2018	<0.1	<0.1	1010	<0.1	<0.1	0.1	0.1	19.7	19.7	2.27	3.93
	28/09/2018	<0.1	<0.1	1024	<0.1	<0.1	0.3	0.3	19.6	19.6	2.31	4.03
	05/10/2018	<0.1	<0.1	1007	<0.1	<0.1	0.2	0.2	20.3	20.3	2.32	4.07
	10/10/2018	<0.1	<0.1	1006	<0.1	<0.1	0.1	0.1	20.0	20.0	2.35	4.03
BH2	06/09/2018	<0.1	<0.1	1010	<0.1	<0.1	0.8	0.8	17.4	17.4	1.55	3.99
	28/09/2018	<0.1	<0.1	1024	<0.1	<0.1	0.3	0.3	17.6	17.6	1.64	4.02
	05/10/2018	<0.1	<0.1	1006	<0.1	<0.1	0.3	0.3	18.9	18.9	1.98	4.1
	10/10/2018	<0.1	<0.1	1006	<0.1	<0.1	0.4	0.4	18.2	18.2	2.05	4.06
BH3	06/09/2018	<0.1	<0.1	1009	<0.1	<0.1	0.5	0.4	20.1	20.1	DRY	2.4
	28/09/2018	<0.1	<0.1	1024	<0.1	<0.1	0.4	0.4	20.1	20.1	DRY	2.32
	05/10/2018	<0.1	<0.1	1006	<0.1	<0.1	0.2	0.2	20.4	20.4	DRY	2.47
	10/10/2018	<0.1	<0.1	1006	<0.1	<0.1	0.5	0.5	19.6	19.6	2.18	2.32

Appendix F

APPROACH TO HUMAN HEALTH

RISK ASSESSMENT

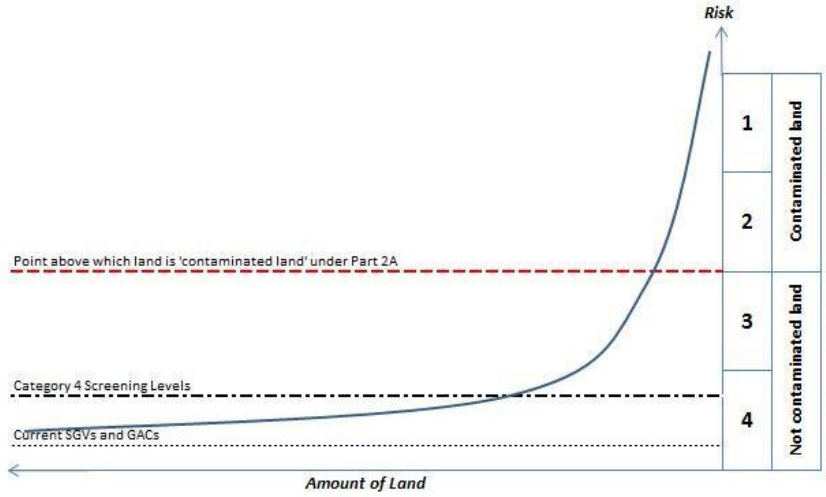
METHODOLOGY FOR THE DERIVATION OF GENERIC QUANTITATIVE ASSESSMENT CRITERIA TO EVALUATE RISKS TO HUMAN HEALTH FROM SOIL & GROUNDWATER CONTAMINATION

UK APPROACH

In the UK, the potential risks to human health from contamination in the ground are usually evaluated through a generic quantitative risk assessment (GQRA) approach. This allows generic and conservative exposure assumptions to be readily applied to risk assessments and can be a useful tool for rapidly screening data and to identify those contaminants or scenarios that could benefit from further investigation and/or site-specific detailed quantitative risk assessment (DQRA). Current industry good practice is to use the approach presented in the Environment Agency (EA) publications SR2[1] and SR3[2]. This approach allows the derivation of Generic Assessment Criteria (GACs), primarily for chronic exposure.

In April 2012, the Department of Environment, Food and Rural Affairs (Defra) published updated statutory guidance[3] which introduced a four category approach to determining whether land in England and Wales is contaminated or not on the grounds of significant possibility of significant harm (SPOSH). **Figure 1** presents a graphical representation of the categories.

Figure 1: Four Categories for Determining if Land Represent a SPOSH



Cases classified as Category 1 are considered to be SPOSH based on actual evidence or an unacceptably high probability of harm existing. Category 4 cases are those where there is no risk, or a low risk of SPOSH.

[1] Environment Agency '*Human Health Toxicological Assessment of Contaminants in Soil',* Report SC050021/SR2. January 2009.
[2] Environment Agency '*Updated Technical Background to the CLEA Model*,' Report SC050021/SR3. January 2009.
[3] Defra '*Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance'.* April 2012.

GACs represent a minimal risk level, well within Category 4. A 2014 publication by Contaminated Land: Applicatons in Real Environments (CL:AIRE),SP1010[4] and endorsed by Defra[5] provided an approach to determine Category 4 Screening Levels (C4SLs) which are higher than the GACs whilst being "more pragmatic but still strongly precautionary". It also provided C4SLs for six contaminants of concern. Although the C4SLs were designed to support Part 2A assessments to determine 'contaminated land' they are specifically mentioned, along with reference to the Part 2A statutory guidance, by the Department for Communities and Local Government (DCLG) for use in a planning context[6].

An updated version the Contaminated Land Exposure Assessment (CLEA) Workbook (v1.071) was released by the EA in September 2015 to take into account the publication of SP1010. The updates comprised: additional toxicity data for the six chemicals for which C4SLs were derived; two new public open space land use scenarios; updated exposure parameters; options to run the model using C4SL exposure assumptions; and increased functionality. There were no changes to algorithms, so it is still possible to replicate the withdrawn SGVs using the input parameters held within v1.071.

It should be noted that the four category approach has not been adopted in Scotland under Part 2A or the planning regime. The Part 2A statutory guidance applicable in Scotland (Paper SE/2006/44 dated May 2006) does not reflect the changes introduced by Defra in April 2012 which allow for the use of C4SLs within Part 2A risk assessments. Additionally, it is considered that the principal of 'minimal risk' should still apply under planning in Scotland, based on current guidance.

WSP APPROACH

Following the withdrawal of the SGVs, and in the absence of an industry-wide, accepted set of GACs it is down to individual practitioners to derive their own soil assessment criteria. WSP has used the approach provided within SR2, SR3, SP1010, CLEA Workbook v1.071and SR4[7] to produce a set of minimal risk GACs. The chemical-specific data within two key publications were considered during their production: CL:AIRE 2010[8] and LQM 2015[9]. Both documents provide comprehensive sets of GACs for different contaminants of concern.

The LQM Suitable For Use Levels (S4ULs) have selected exposure parameters someway between those of the SR3 land uses and the C4SL exposure scenarios. This approach was rejected by WSP as not representing minimal risk, however, the LQM S4UL document was critically reviewed and the approach and chemical input parameters were utilised where considered to be appropriate.

An industry-led C4SL Working Group is in the process of deriving a larger set of C4SLs in the near future, for approximately 20 contaminants. This will include a critical review of the chemical input data for all selected substances, and may therefore lead to further amendments to the chemical input data used in the WSP in-house screening values. It is considered likely that the contaminant list will

[4] CL:AIRE *'Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination'* SP1010, Final Project Report (Revision 2). September 2014.
[5] Defra 'SP1010: *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document'*. December 2014.
[6] DCLG Planning Practice Guidance '*Land Affected by Contamination'*, particularly Paragraphs 001 and 007. Ref IDs: 33-001-20140306 & 33-007-20140612.
[7] Environment Agency '*CLEA Software (Version 1.05) Handbook (and Software)',* Report SC050021/SR4. September 2009.
[8] CL:AIRE 'The EIC/AGS/CL:AIRE *Soil Generic Assessment Criteria for Human Health Risk Assessment'.* ISBN 978-1-05046-20-1. January 2010.
[9] Nathanail et al '*The LQM/CIEH S4ULs for Human Health Risk Assessment*', Land Quality Press, ISBN 978-0-9931084-0-2. 2015.

crossover with the current CL:AIRE GACs. As such, this document was not critically reviewed by WSP.

WSP's current approach to the assessment of risks to human health is to continue to evaluate minimal risk through the use of in-house derived GACs, and to use the published C4SLs as a secondary tier of assessment until such time as additional C4SLs are published and/or in-house values are derived.

EXPOSURE MODELS

LAND USES

WSP has largely adopted the exposure assumptions of the generic land use scenarios included within SR3, with two additional public open space scenarios included from within SP1010:

- Residential with homegrown produce consumption;
- Residential without homegrown produce consumption;
- Allotments;
- Commercial;
- Public open space near residential housing (POS_{resi}); and
- Public park (POS_{park}).

Exceptions are described in the following Sections.

SOIL PROPERTIES

SR3 assumes a sandy loam soil with a pH of 7 and a Soil Organic Matter (SOM) content of 6% for its generic land uses, based on the geographical spread of topsoils in the UK. WSP has adopted these default values. In addition, GACs based on an SOM of 1% and 2.5% have been derived, based on common experience of the nature of Made Ground and lack of topsoil on many brownfield sites.

RECEPTOR CHARACTERISTICS AND BEHAVIOURS

SP1010 provides some updated exposure parameters for long-term inhalation rates[10] and the consumption rates for homegrown produce[11] compared to those provided in SR3. This data was used to derived WSP's GACs.

The changes in inhalation rates do not apply to the allotment generic land use scenario, as these are based on the breathing rates for short-term exposure of light to moderate intensity activity which were derived from a study that was not updated in USEPA 2011, so the SR3 rates were retained.

[10] USEPA, National Centre for Environmental Assessment '*Exposure Factors Handbook: 2011 Edition*' EPA/600/R-09/052F. September 2011.
[11] National Diet and Nutrition Survey 2008/2009 to 2010/2011.

CHEMICAL DATA

PHYSICO-CHEMICAL PARAMETERS

Physico-chemical properties for the contaminants for which GACs have been derived have been obtained following critical review of the following hierarchy of data sources:

1. Environment Agency/Defra SGV reports where available.
2. Environment Agency '*Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values*', Report SC050021/SR7, November 2008.
3. Published fate and transport reviews within Nathanail et. al 2015 and CL:AIRE 2010.

Where appropriate, and where sufficient data is available, values were adjusted to reflect a UK soil temperature of 10ºC (e.g. K_{aw}).

TOXICOLOGICAL DATA

Toxicological data for the derivation of minimal risk Health Criteria Values (HCV) for each contaminant was selected with due regard to the approach presented in SR2. Where appropriate, the following hierarchy of data sources was used:

1. UK toxicity reviews published by authoritative bodies including:
   - EA;
   - Public Health England (PHE);
   - Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT); and
   - Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment (COC).
2. Authoritative European sources such as European Food Standards Agency (EFSA)
3. International organisations including:
   - World Health Organisation (WHO); and
   - Joint FAO/WHO Expert Committee on Food Additives (JECFA).
4. Authoritative country-specific sources including:
   - United States Environmental Protection Agency (USEPA);
   - US Agency for Toxic Substances and Disease Registry (ATSDR);
   - US Integrated Risk Information System (IRIS); and
   - Netherlands National Institute for Public Health and the Environment (RIVM).

Factors such as the applicability of the data to human health (e.g. epidemiological vs. animal studies), the quality of the data, the level of uncertainty in the results and the age of the data were also taken into account in the final selection. Details for specific substances are available on request.

MEAN DAILY INTAKES

Estimations of background exposure for each threshold substance have been updated. In line with the SR2 approach, the exposure from non-threshold substances in the soil does not take into account exposure from other sources, and as such GACs were derived without consideration of the Mean Daily Intake (MDI) for those substances.

The data published by the EA in its series of TOX reports between 2002 and 2009 was evaluated to determine whether the values were considered to remain valid today. Values from these current UK published sources were not amended unless they were considered to be significantly different so that the GACs remained as comparable as possible with the revoked SGVs.

ORAL MEAN DAILY INTAKES

Oral MDI were generally estimated as the sum of exposure via the ingestion of food and drinking water using the default adult physiological parameters presented in Table 3.3 of SR2.

Data on the exposure of substances from food ingestion was generally obtained from UK Total Diet Studies (TDS) published by the Food Standards Agency (FSA) and its predecessor the Ministry of Agriculture, Fisheries and Food (MAFF) and from studies commissioned by COT. Where no UK-specific data was available, MDI were derived from the European Food Safety Authority (EFSA), Health Canada and US sources. This was a rare occurrence, and in these instances, the data was evaluated to determine its applicability to the UK.

Data on the concentrations of substances in tap water was obtained from a variety of sources. UK data was used where available, with preference given to Drinking Water Inspectorate (DWI) 2014 data from water company tap water testing (LOD, 1st and 99th percentile data is available). Where the substance was not included in tap water testing, other UK sources of information were considered including:

- à DWI data from water company tap water testing from previous years;
- à COT; and
- à FSA.

Where UK data was not available, a number of other data sources were considered, largely WHO International Programme on Chemical Safety (IPCS) Concise International Chemical Assessment Documents (CICADs) and background documents for the development of Guidelines for Drinking Water Quality, using professional judgement on the relevance of the data to the UK. The final decision on the MDI from drinking water was made using professional judgement on the balance of relevance and probability, taking into account the detection limit where not detected, Koc and solubility, reduction in use of the substance, banned substances, tight controls (e.g. on explosives) and with due consideration to the SR2 instruction that “if no data or information in background exposure are available, background exposure should be assumed to be negligible and the MDI set to zero….”.

Data from other countries was generally not used because it was considered that the hydrogeology of these countries along with industrial practices were unlikely to be reflective of the UK.

INHALATION MEAN DAILY INTAKES

Inhalation MDIs were based on estimates of average daily exposure by the inhalation pathway and calculated using the default adult physiological parameters presented in Table 3.3 of SR2.

The inhalation MDIs were generally estimated using background exposure data from the UK, derived from Defra's UK-AIR: Air Information Resource[12], which provides ambient air quality data from a number of sites forming a UK-wide monitoring network. The MDIs for heavy metals were based on rolling annual average metal mass concentration data from Defra's UK Heavy Metals Monitoring Network from the period October 2009 to September 2010[13].

Information for some substances was obtained from UK sources including Environment Agency TOX reports and data from the UK Expert Panel on Air Quality Standards (EPAQS). Where recent UK data was not available, data was sourced from the International Programme on Chemical Safety (IPCS), the World Health Organisation (WHO), the Agency for Toxic Substances and Diseases Registry (ATSDR), Health Canada, and various other peer-reviewed sources summarised by LQM/CIEH[14].

For other substances, where no data or information on background exposure was available, background exposure was assumed to be negligible and the MDI set at 0.5*TDI in accordance with guidance in SR2.

PLANT UPTAKE

Soil to plant concentration factors are available in CLEA v1.071 for arsenic, cadmium, hexavalent chromium, lead, mercury, nickel and selenium. For all remaining inorganic chemicals, concentration factors were obtained using the PRISM model. Substance-specific correction factors have been selected in accordance with the guidance established within SR3. This is consistent to the approach utilised in the derivation of the LQM S4UL values and the EIC/AGS/CL:AIRE GAC.

Where there is a lack of appropriate data to enable the derivation of specific soil to plant concentrations factors for organic chemicals, plant uptake was modelled within CLEA v1.071 using the generic equations recommended within SR3, as follows:

- Green Vegetables – Ryan et al. (1988);
- Root Vegetables – Trapp (2002);
- Tuber Vegetables – Trapp et al. (2007); and
- Tree Fruit – Trapp et al. (2003).

There are no suitable models available for modelling uptake for herbaceous fruit or shrub fruit. Exposure is considered negligible.

[12] Crown 2016 copyright Defra via uk-air.defra.gov.uk, licenced under the Open Government Licence (OGL).
[13] Defra, 2013 Spreadsheet of historic data for multiple years for the Metals network. Available online at: http://uk-air.defra.gov.uk/data/metals-data. [Accessed 13/03/2016].
[14] LQM/CIEH, 2015. The LQM/CIEH S4ULs for Human Health Risk Assessment.

SOIL SATURATION LIMITS

GACs are not limited to their theoretical soil saturation within CLEA, although where either the aqueous or the vapour-based saturation is exceeded, this is highlighted within the Workbook (compared with the lower of the two values). This affects pathways which depend on partitioning calculations so in reality this only affects the vapour pathways and is relevant to organic substances and other substances, such as elemental mercury, that have a significant volatile component. However, the Workbook highlights saturation for direct contact pathways to indicate to the user where further qualitative consideration of free phase contamination at surface may be required.

Where the lower of the two saturation limits is exceeded and the vapour pathway is the only exposure route being considered, the chronic risks to human health are likely to be negligible. Further evaluation could be undertaken using an alternative model suitable for evaluating non-aqueous phase liquids (NAPLs), such as the Johnson & Ettinger (J&E) approach described in USEPA 2003. However, WSP considers that if NAPLs are suspected, given the known limitations and over-simplifications of J&E, soil vapour monitoring is a more accurate way of assessing potential risks.

Where the lower saturation limit is exceeded for the vapour pathway and a number of exposure routes are being considered, then the contribution from the NAPL via vapour inhalation to the overall exposure can be evaluated using the procedure provided in SR4. WSP would evaluate this as part of a DQRA process or through soil vapour monitoring on-site to determine site-specific soil vapour concentrations.

CHEMICAL SPECIFIC ASSUMPTIONS

CYANIDES

Cyanide has high acute toxicity, and short term exposure is an important consideration when assessing the risks from soils contaminated with cyanide. The primary risk to human receptors from free cyanide in soils is an acute risk.

There is no current UK guidance available for calculating acute risks from free cyanide. Consequently, GAC for acute exposure were derived using the algorithms presented in MADEP 1992[15] and assuming a one-off ingestion of 10g of soil (this conservative value has been taken as an upper bound estimate for a one-off soil ingestion rate amongst children). Receptor body weights have been selected according to the critical receptor for each exposure scenario. The lowest of the chronic and acute GAC for each land use scenario were adopted by WSP. Brinckerhoff.

LEAD

The SGV for lead was withdrawn by the EA in 2009, and in 2011 the EA withdrew their published TOX report in light of new scientific evidence. The C4SL for lead was derived using the latest scientific evidence from a large human dataset. As such, no chemical-specific margin was applied in the derivation of the C4SL for lead. It may be possible for WSP to derive a GAC for lead using the same dataset and applying a chemical-specific margin, but the value is likely to be lower than UK natural background concentrations. Therefore, WSP has adopted the toxicological data used to derive the C4SLs in deriving the GAC for lead until such time as alternative GACs are published by an authoritative body. The relative bioavailability was set at 100% in line with the approach taken for other GACs, whereas the C4SL assumes 60% for soil and 64% for airborne dust. Thus, the WSP GAC are lower than the C4SLs.

[15] MADEP '*Background Documentation for the Development of an "Available Cyanide" Benchmark Concentration'* 1992. http://www.mass.gov/dep/toxics/cn_soil.htm

POLYCYCLIC AROMATIC HYDROCARBONS

WSP's approach to the assessment of polycyclic aromatic hydrocarbons (PAHs) uses the surrogate marker approach. BaP was used as a surrogate marker for all genotoxic PAHs in line with the Health Protection Agency 2010[16] recommendations and SP1010. This assumes that the PAH profile of the data is similar to that of the coal tars used in the Culp *et al* oral carcinogenicity study from which the toxicity data for BaP was produced. In reality, this profile has been shown by HPA to be applicable on the majority of contaminated sites based on assessment of sites across the country.

The alternative is the Toxic Equivalency Factor (TEF) approach which uses a reference compound and assigns TEFs for other compounds based on estimates of potency. Key uncertainties with this approach include the assumption that all compounds have the same toxic mechanism of action within the body and that no compounds with a greater potency than the reference compound are present. It is considered by the HPA that the TEF approach is likely to under predict the true carcinogenicity of PAHs and therefore favours the surrogate marker approach.

For these reasons, WSP considers that the adoption of BaP as a surrogate marker for genotoxic PAHs as opposed to the TEF approach is reasonable, even in cases where the PAH profile may differ from that of the Culp *et al* study. In addition, WSP has derived a GAC for naphthalene, which is commonly a risk driver due to its high volatility, relative to other PAH compounds, as an indicator compound for threshold PAHs.

CHEMICAL GROUPS

For a number of chemical groups, the available toxicity data is for combinations of chemicals. Given that the physico-chemical parameters may differ between the chemicals, the GACs for the chemicals within the groups have been calculated and then the lowest GAC selected to represent the entire group. This was the approach taken by the EA for m-, o- and p-xylenes, and has also been adopted by WSP for:

- 2-chlorophenol, 2,4-dichlorophenol, 2,4,6-trichlorophenol and 2,3,4,6-tetrachlorophenol;
- 2-, 3- and 4-methylphenol (total cresols);
- aldrin and dieldrin;
- α- and β-endosulphan; and
- trimethylbenzenes.

EXPOSURE TO VAPOURS

INHALATION OF MEASURED VAPOURS

WSP has derived a set of soil vapour GACs (GAC_{SV}) that allow for the assessment of measured site soil vapour concentrations, using J&E, in order to establish potential risks via indoor inhalation of vapours. This methodology enables a more robust assessment of exposure via the inhalation of soil vapours indoors than using CLEA-derived soil GAC, as it is based upon measured soil vapour concentrations beneath the site. It also allows for the assessment of vapours from all source terms (i.e. groundwater, soil or NAPL). Outdoor inhalation was not included. WSP considers that the indoor inhalation pathway is the significantly dominant risk-driver.

[16] HPA Contaminated Land Information Sheet '*Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs)* 2010

The generic land use scenarios within CLEA (residential and commercial) that were used to derive the soil GAC were used to define the receptor and building characteristics for the soil vapour GAC. Only residential and commercial generic land use scenarios include the indoor inhalation of vapours pathway.

The GAC_{sv} were derived for three different soil types; sand, sandy loam and clay, reflecting the importance of this parameter within the J&E model. A depth to contamination of 0.85 m below the base of the building foundation was assumed (i.e. 1 m below ground level). This differs from the depth assumed for the soil GAC (0.5 m bgl), but was selected by WSP as a reasonable worst case scenario.

It is acknowledged that the J&E commonly over-predicts indoor vapour concentrations. In particular, it will significantly over-predict vapour concentrations for suspended floor slabs, which many new builds are constructed with, it does not take into account lateral migration and assumes an infinite source of contamination at steady state conditions. In addition, it is common for soil gas/vapour wells to be installed with at least 1 m of plain riser at the surface and this equates to a total depth of 0.85 m below the building foundation plus a 0.15 m thick foundation, and so is more representative of the depth that samples will be taken from.

The TDSIs and IDs for each substance were converted from $\mu gkg^{-1}{}_{bw}day^{-1}$ to μgm^{-3} using the standard conversions quoted in Table 3.3 of SR2, thereby replacing the need to model C_{air} in the equation:

$$C_{air} = \alpha . C_{vap} . 1{,}000{,}000 cm^3 m^{-3}$$

Where:

C_{air} is the concentration of vapours within the building, mg^{-3}

α is the steady state attenuation coefficient between soil and indoor air, dimensionless

C_{vap} is the soil vapour concentration, $mgcm^{-3}$

The target concentrations within indoor air for each substance (C_{air}) are a function of receptor inhalation rates and occupancy periods, as defined by the site conceptual exposure model (assuming standard CLEA occupancy periods and receptors).

The attenuation factor was calculated using J&E (Equation 10.4 in SR3) and the resulting C_{vap} is equivalent to the GAC_{sv} for the modelled exposure scenario.

Where the calculated GAC_{sv} for a substance exceeds the vapour saturation limit, no GAC_{sv} has been proposed.

INHALATION OF GROUNDWATER-DERIVED VAPOURS

The CLEA model does not have the capacity to derive GACs to assess vapours derived from dissolved phase contamination. WSP has derived a set of groundwater GACs (GAC_{gw}) to evaluate the potential risks through the indoor inhalation of groundwater-derived vapours by first applying the approach described above for the derivation of the WSP GAC_{sv} to determine the acceptable concentration in soil vapour directly above the water table.

The depth to groundwater was assumed to be 1 m bgl (i.e. 0.85 m below the base of the building foundation). This depth was considered to be more representative of commonly encountered groundwater conditions than the 0.5 m below the base of the building foundation (i.e. 0.65 m bgl) that is used by CLEA for an unsaturated source present in the overlying soil.

The GAC_{gw} was then back-calculated from the GAC_{sv} using the air-water partition coefficient (K_{aw}) for each substance.

Where the calculated GAC_{gw} for a substance exceeds the solubility limit, no GAC_{gw} has been proposed.

Appendix G

HUMAN HEALTH SOIL GQRA

PRE-REPORT DATA CHECK

All GEOL_GEO2 codes are complete.

All GEOL_GEO2 codes are recognised and suitable for this report.

All SampleMatrix fields are complete

Commercial, SOM=1%

Site Area(s): Whole site
Phase(s): All phases

Aliphatics and Aromatics

Result > Assessment Criteria

Limit of detection > Assessment Criteria

Analyte	Units	LOD	GAC	PointID	BH1		BH2	BH3
					0.8 - 0.9	2.2 - 2.3	0.7 - 0.8	0.65 - 0.75
				Depth (m bgl)	22/08/18	22/08/18	29/08/18	24/08/18
				Sample Date				
				Geology (at top depth of sample)	Made Ground Granular	Till	Till	Made Ground Cohesive
Aliphatic C05-C06	mg/kg	0.010	3,190		<0.01	<0.01	<0.01	<0.01
Aliphatic C06-C08	mg/kg	0.010	7,780		<0.01	<0.01	<0.01	<0.01
Aliphatic C08-C10	mg/kg	0.010	2,000		<0.01	<0.01	<0.01	<0.01
Aliphatic C10-C12	mg/kg	0.010	9,690		<0.01	<0.01	<0.01	<0.01
Aliphatic C12-C16	mg/kg	0.10	58,800		<0.1	0.874	<0.1	<0.1
Aliphatic C35-C44	mg/kg	0.10	1,910,000		1.18	<0.1	<0.1	0.827
Aromatic C07-C08	mg/kg	0.010	56,100		<0.01	<0.01	<0.01	<0.01
Aromatic C08-C10	mg/kg	0.010	3,460		<0.01	<0.01	<0.01	<0.01
Aromatic C10-C12	mg/kg	0.010	16,200		<0.01	<0.01	<0.01	<0.01
Aromatic C12-C16	mg/kg	0.10	36,200		<0.1	<0.1	<0.1	<0.1
Aromatic C16-C21	mg/kg	0.10	28,600		<0.1	0.756	1.72	<0.1
Aromatic C21-C35	mg/kg	0.10	28,600		3.11	5.39	6.45	3.74
Aromatic C35-C44	mg/kg	0.10	28,600		<0.1	0.536	0.611	1.03

Commercial, SOM=1%

Site Area(s): Whole site
Phase(s): All phases

BTEX and Fuel Additives

Result > Assessment Criteria

Limit of detection > Assessment Criteria

Analyte	Units	LOD	GAC	PointID	BH1		BH2	BH3
					0.8 - 0.9	2.2 - 2.3	0.7 - 0.8	0.65 - 0.75
				Depth (m bgl)	22/08/18	22/08/18	29/08/18	24/08/18
				Sample Date				
				Geology (at top depth of sample)	Made Ground Granular	Till	Till	Made Ground Cohesive
Benzene	mg/kg	0.090	27.0		<0.09	<0.09	<0.09	<0.09
Ethylbenzene	mg/kg	0.040	5,710		<0.04	<0.04	<0.04	<0.04
Methyl t-butylether (MTBE)	mg/kg	0.10	7,480		<0.1	<0.1	<0.1	<0.1
Toluene	mg/kg	0.070	56,300		<0.07	<0.07	<0.07	<0.07
Xylene - Total (Summed)	mg/kg	-999	5,920		0.1	0.1	0.1	0.1
Xylene-m & p	mg/kg	0.10	5,920		<0.1	<0.1	<0.1	<0.1
Xylene-o	mg/kg	0.10	5,920		<0.1	<0.1	<0.1	<0.1

Commercial, SOM=1%

Site Area(s): Whole site
Phase(s): All phases

Metals

Result > Assessment Criteria

Limit of detection > Assessment Criteria

Analyte	Units	LOD	GAC	PointID	BH1		BH2	BH3
					0.8 - 0.9	2.2 - 2.3	0.7 - 0.8	0.65 - 0.75
				Depth (m bgl)	22/08/18	22/08/18	29/08/18	24/08/18
				Sample Date				
				Geology (at top depth of sample)	Made Ground Granular	Till	Till	Made Ground Cohesive
Arsenic	mg/kg	0.60	635		<0.6	5.15	8.15	1.59
Cadmium	mg/kg	0.020	223		0.302	0.0412	0.589	0.916
Copper	mg/kg	1.40	69,800		2.67	22.9	22.9	6.75
Lead	mg/kg	0.70	1,390		3.53	10.2	14.3	21.9
Mercury	mg/kg	0.14	1,110		<0.14	<0.14	<0.14	<0.14
Nickel	mg/kg	0.20	1,710		4.64	36.1	37.2	9.66
Selenium	mg/kg	1.00	12,300		<1	<1	<1	<1
Zinc	mg/kg	1.90	1,050,000		27.1	85.8	95.9	47.8

Commercial, SOM=1%

Site Area(s): Whole site
Phase(s): All phases

PAHs

Result > Assessment Criteria

Limit of detection > Assessment Criteria

Analyte	Units	LOD	GAC	PointID	BH1		BH2	BH3
					0.8 - 0.9	2.2 - 2.3	0.7 - 0.8	0.65 - 0.75
				Depth (m bgl)	22/08/18	22/08/18	29/08/18	24/08/18
				Sample Date				
				Geology (at top depth of sample)	Made Ground Granular	Till	Till	Made Ground Cohesive
Benzo (a) pyrene	mg/kg	0.015	38.0		0.0362	<0.015	<0.015	<0.015
Naphthalene	mg/kg	0.009	193		<0.009	<0.009	<0.009	<0.009

Appendix H

GROUNDWATER VAPOUR GAC

Region	Wales and England	**Hardness**	NA
Water Body	Groundwater	**Recieving surface water status**	NA
Water Body Type	NA		
Surface Water Type	NA	**Altitude**	NA

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

Unrecognised analytes — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
C16-C35 Aromatics (Unrecognised code)	10.00	5.00	10.00	-		ug/l	2	-	0	

Aliphatics and Aromatics — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Aliphatic C05-C06	10.00	5.00	10.00	15,000	WHO 2008	ug/l	2	-	0	
Aliphatic C06-C08	10.00	5.00	10.00	15,000	WHO 2008	ug/l	2	-	0	
Aliphatic C08-C10	10.00	5.00	10.00	300	WHO 2008	ug/l	2	-	0	
Aliphatic C10-C12	10.00	5.00	10.00	300	WHO 2008	ug/l	2	-	0	
Aliphatic C12-C16	10.00	5.00	10.00	300	WHO 2008	ug/l	2	-	0	
Aliphatic C16-C21	10.00	5.00	10.00	-		ug/l	2	-	0	
Aliphatic C16-C35	10.0	19.5	34.0	-		ug/l	2	1	0	
Aliphatic C21-C35	10.0	19.5	34.0	-		ug/l	2	1	0	
Aliphatics C12-C35	10.0	19.5	34.0	-		ug/l	2	1	0	

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

Aliphatics and Aromatics — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Aromatic C06-C07	10.00	5.00	10.00	-		ug/l	2	-	0	
Aromatic C07-C08	10.00	5.00	10.00	-		ug/l	2	-	0	
Aromatic C08-C10	10.00	5.00	10.00	300	WHO 2008	ug/l	2	-	0	
Aromatic C10-C12	10.00	5.00	10.00	90.0	WHO 2008	ug/l	2	-	0	
Aromatic C12-C16	10.00	5.00	10.00	90.0	WHO 2008	ug/l	2	-	0	
Aromatic C12-C35	10.00	5.00	10.00	-		ug/l	2	-	0	
Aromatic C16-C21	10.00	5.00	10.00	90.0	WHO 2008	ug/l	2	-	0	
Aromatic C21-C35	10.00	5.00	10.00	90.0	WHO 2008	ug/l	2	-	0	
Total Aliphatics and Aromatics (C5-C35)	10.0	19.5	34.0	-		ug/l	2	1	0	

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

BTEX and Fuel Additives — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Benzene	1.00	0.50	1.00	1.00	UK DWS	ug/l	2	-	0	
Ethylbenzene	1.00	0.50	1.00	300	WHO 2017	ug/l	2	-	0	
Methyl t-butylether (MTBE)	1.00	0.50	1.00	15.0	WHO 2017	ug/l	2	-	0	
Tertiary Amyl Methyl Ether (TAME)	1.00	0.50	1.00	-		ug/l	2	-	0	
Toluene	1.00	0.50	1.00	700	WHO 2017	ug/l	2	-	0	
Xylene	2.00	1.00	2.00	500	WHO 2017	ug/l	2	-	0	
Xylene-m & p	1.00	0.50	1.00	-		ug/l	2	-	0	
Xylene-o	1.00	0.50	1.00	-		ug/l	2	-	0	

Inorganics — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Sulphate as SO4	71500	161250	251000	250,000	UK DWS	ug/l	2	2	1	BH2

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

Metals — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Arsenic	8.7	11.9	15.1	10.0	UK DWS	ug/l	2	2	1	BH2
Cadmium	0.51	0.83	1.14	5.00	UK DWS	ug/l	2	2	0	
Chromium	30.4	54.8	79.1	50.0	UK DWS	ug/l	2	2	1	BH2
Copper	24.6	46.8	69.0	2,000	UK DWS	ug/l	2	2	0	
Hexavalent Chromium	3.00	1.50	3.00	-		ug/l	2	-	0	
Lead	13.5	26.1	38.7	10.0	UK DWS	ug/l	2	2	2	BH1, BH2
Mercury	0.020	0.056	0.101	1.00	UK DWS	ug/l	2	1	0	
Nickel	52.2	78.1	104.0	20.0	UK DWS	ug/l	2	2	2	BH1, BH2
Selenium	2.96	4.17	5.38	10.0	UK DWS	ug/l	2	2	0	
Zinc	134	156	177	-		ug/l	2	2	0	

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

PAHs — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Acenaphthene	0.005	0.003	0.005	-		ug/l	2	-	0	
Acenaphthylene	0.005	0.003	0.005	-		ug/l	2	-	0	
Anthracene	0.005	0.003	0.005	-		ug/l	2	-	0	
Benzo (a) anthracene	0.005	0.003	0.005	-		ug/l	2	-	0	
Benzo (a) pyrene	0.002	0.001	0.002	0.010	UK DWS	ug/l	2	-	0	
Benzo (b) fluoranthene	0.005	0.003	0.005	-		ug/l	2	-	0	
Benzo (ghi) perylene	0.005	0.003	0.005	-		ug/l	2	-	0	
Benzo (k) fluoranthene	0.005	0.003	0.005	-		ug/l	2	-	0	
Chrysene	0.005	0.003	0.005	-		ug/l	2	-	0	
Dibenzo (ah) anthracene	0.005	0.003	0.005	-		ug/l	2	-	0	
Fluoranthene	0.005	0.015	0.027	-		ug/l	2	1	0	
Fluorene	0.005	0.003	0.005	-		ug/l	2	-	0	
Indeno (1,2,3-cd) pyrene	0.005	0.003	0.005	-		ug/l	2	-	0	
Naphthalene	0.010	0.005	0.010	-		ug/l	2	-	0	
PAH (Total)	0.082	0.041	0.082	-		ug/l	2	-	0	
Phenanthrene	0.005	0.003	0.005	-		ug/l	2	-	0	
Pyrene	0.005	0.019	0.035	-		ug/l	2	1	0	

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

TPH/EPH — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
GRO Surrogate	101	101	101	-		%	2	2	0	
PRO (C5-C12)	50.0	25.0	50.0	-		ug/l	2	-	0	

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

BTEX and Fuel Additives — Aquifer: N/A

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Xylene - Total (Summed)	1.00	1.00	1.00	-		ug/l	2	2	0	

EXCEEDANCES OF THRESHOLDS

Sample matrix: WATER

Inorganics

Analyte	Point ID	Response Zone Depth (M)	Result	Criteria Source	Threshold	Units	Stratum
Sulphate as SO4	BH2	1 - 4	251000	UK DWS	250000	ug/l	Till

Metals

Analyte	Point ID	Response Zone Depth (M)	Result	Criteria Source	Threshold	Units	Stratum
Arsenic	BH2	1 - 4	15.1	UK DWS	10.0	ug/l	Till
Chromium	BH2	1 - 4	79.1	UK DWS	50.0	ug/l	Till
Lead	BH1	1 - 4	13.5	UK DWS	10.0	ug/l	Made Ground Granular / Till
	BH2	1 - 4	38.7	UK DWS	10.0	ug/l	Till
Nickel	BH1	1 - 4	52.2	UK DWS	20.0	ug/l	Made Ground Granular / Till
	BH2	1 - 4	104	UK DWS	20.0	ug/l	Till

Region	Wales and England
Water Body	Surface water
Water Body Type	Inland
Surface Water Type	River or Stream

Hardness	0-50 mg/l
Recieving surface water status	Good (or below)
Altitude	< 80m Elevation

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

Unrecognised analytes — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
C16-C35 Aromatics (Unrecognised code)	10.00	5.00	10.00	-		ug/l	2	-	0	

Aliphatics and Aromatics — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Aliphatic C05-C06	10.00	5.00	10.00	-		ug/l	2	-	0	
Aliphatic C06-C08	10.00	5.00	10.00	-		ug/l	2	-	0	
Aliphatic C08-C10	10.00	5.00	10.00	-		ug/l	2	-	0	
Aliphatic C10-C12	10.00	5.00	10.00	-		ug/l	2	-	0	
Aliphatic C12-C16	10.00	5.00	10.00	-		ug/l	2	-	0	
Aliphatic C16-C21	10.00	5.00	10.00	-		ug/l	2	-	0	
Aliphatic C16-C35	10.0	19.5	34.0	-		ug/l	2	1	0	
Aliphatic C21-C35	10.0	19.5	34.0	-		ug/l	2	1	0	
Aliphatics C12-C35	10.0	19.5	34.0	-		ug/l	2	1	0	

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

Aliphatics and Aromatics — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Aromatic C06-C07	10.00	5.00	10.00	10.0	CL:AIRE 2017	ug/l	2	-	0	
Aromatic C07-C08	10.00	5.00	10.00	74.0	CL:AIRE 2017	ug/l	2	-	0	
Aromatic C08-C10	10.00	5.00	10.00	20.0	CL:AIRE 2017	ug/l	2	-	0	
Aromatic C10-C12	10.00	5.00	10.00	2.00	CL:AIRE 2017	ug/l	2	-	0	
Aromatic C12-C16	10.00	5.00	10.00	2.00	CL:AIRE 2017	ug/l	2	-	0	
Aromatic C12-C35	10.00	5.00	10.00	-		ug/l	2	-	0	
Aromatic C16-C21	10.00	5.00	10.00	0.10	CL:AIRE 2017	ug/l	2	-	0	
Aromatic C21-C35	10.00	5.00	10.00	0.0002	CL:AIRE 2017	ug/l	2	-	0	
Total Aliphatics and Aromatics (C5-C35)	10.0	19.5	34.0	-		ug/l	2	1	0	

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

BTEX and Fuel Additives — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Benzene	1.00	0.50	1.00	10.0	EQS 2015	ug/l	2	-	0	
Ethylbenzene	1.00	0.50	1.00	20.0	Proposed EQS	ug/l	2	-	0	
Methyl t-butylether (MTBE)	1.00	0.50	1.00	-		ug/l	2	-	0	
Tertiary Amyl Methyl Ether (TAME)	1.00	0.50	1.00	-		ug/l	2	-	0	
Toluene	1.00	0.50	1.00	74.0	EQS 2015	ug/l	2	-	0	
Xylene	2.00	1.00	2.00	30.0	CL:AIRE 2017	ug/l	2	-	0	
Xylene-m & p	1.00	0.50	1.00	-		ug/l	2	-	0	
Xylene-o	1.00	0.50	1.00	-		ug/l	2	-	0	

Inorganics — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Sulphate as SO4	71500	161250	251000	-		ug/l	2	2	0	

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

Metals — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Arsenic	8.7	11.9	15.1	50.0	EQS 2015	ug/l	2	2	0	
Cadmium	0.51	0.83	1.14	0.080	EQS 2015	ug/l	2	2	2	BH1, BH2
Chromium	30.4	54.8	79.1	4.70	EQS 2015	ug/l	2	2	2	BH1, BH2
Copper	24.6	46.8	69.0	1.00	EQS 2015 - Bioavailable	ug/l	2	2	2	BH1, BH2
Hexavalent Chromium	3.00	1.50	3.00	3.40	EQS 2015	ug/l	2	-	0	
Lead	13.5	26.1	38.7	1.20	EQS 2015 - Bioavailable	ug/l	2	2	2	BH1, BH2
Mercury	0.020	0.056	0.101	0.070	EQS 2015 MAC	ug/l	2	1	1	BH2
Nickel	52.2	78.1	104.0	4.00	EQS 2015 - Bioavailable	ug/l	2	2	2	BH1, BH2
Selenium	2.96	4.17	5.38	-		ug/l	2	2	0	
Zinc	134	156	177	10.9	EQS 2015 - Bioavailable	ug/l	2	2	2	BH1, BH2

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

PAHs — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Acenaphthene	0.005	0.003	0.005	-		ug/l	2	-	0	
Acenaphthylene	0.005	0.003	0.005	-		ug/l	2	-	0	
Anthracene	0.005	0.003	0.005	0.10	EQS 2015	ug/l	2	-	0	
Benzo (a) anthracene	0.005	0.003	0.005	-		ug/l	2	-	0	
Benzo (a) pyrene	0.002	0.001	0.002	0.0002	EQS 2015	ug/l	2	-	0	
Benzo (b) fluoranthene	0.005	0.003	0.005	-		ug/l	2	-	0	
Benzo (ghi) perylene	0.005	0.003	0.005	-		ug/l	2	-	0	
Benzo (k) fluoranthene	0.005	0.003	0.005	-		ug/l	2	-	0	
Chrysene	0.005	0.003	0.005	-		ug/l	2	-	0	
Dibenzo (ah) anthracene	0.005	0.003	0.005	-		ug/l	2	-	0	
Fluoranthene	0.005	0.015	0.027	0.006	EQS 2015	ug/l	2	1	1	BH2
Fluorene	0.005	0.003	0.005	-		ug/l	2	-	0	
Indeno (1,2,3-cd) pyrene	0.005	0.003	0.005	-		ug/l	2	-	0	
Naphthalene	0.010	0.005	0.010	2.00	EQS 2015	ug/l	2	-	0	
PAH (Total)	0.082	0.041	0.082	-		ug/l	2	-	0	
Phenanthrene	0.005	0.003	0.005	-		ug/l	2	-	0	
Pyrene	0.005	0.019	0.035	-		ug/l	2	1	0	

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

TPH/EPH — Aquifer: 0

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
GRO Surrogate	101	101	101	-		%	2	2	0	
PRO (C5-C12)	50.0	25.0	50.0	-		ug/l	2	-	0	

Sample Matrix: WATER

Site Area(s) Selected: Whole site
Event(s) Selected: All events

BTEX and Fuel Additives — Aquifer: N/A

Analyte	Min	Mean*	Max	Assessment Criteria (AC)	Assessment Criteria Source	Units	No. Locations Sampled	No. Samples > LOD	No. Locations > AC	Location(s) Failing Screening
Xylene - Total (Summed)	1.00	1.00	1.00	-		ug/l	2	2	0	

EXCEEDANCES OF THRESHOLDS

Sample matrix: WATER

Metals

Analyte	Point ID	Response Zone Depth (M)	Result	Criteria Source	Threshold	Units	Stratum
Cadmium	BH1	1 - 4	0.51	EQS 2015	0.080	ug/l	Made Ground Granular / Till
	BH2	1 - 4	1.14	EQS 2015	0.080	ug/l	Till
Chromium	BH1	1 - 4	30.4	EQS 2015	4.70	ug/l	Made Ground Granular / Till
	BH2	1 - 4	79.1	EQS 2015	4.70	ug/l	Till
Copper	BH1	1 - 4	24.6	EQS 2015 - Bioavailable	1.00	ug/l	Made Ground Granular / Till
	BH2	1 - 4	69.0	EQS 2015 - Bioavailable	1.00	ug/l	Till
Lead	BH1	1 - 4	13.5	EQS 2015 - Bioavailable	1.20	ug/l	Made Ground Granular / Till
	BH2	1 - 4	38.7	EQS 2015 - Bioavailable	1.20	ug/l	Till
Mercury	BH2	1 - 4	0.10	EQS 2015 MAC	0.070	ug/l	Till
Nickel	BH1	1 - 4	52.2	EQS 2015 - Bioavailable	4.00	ug/l	Made Ground Granular / Till
	BH2	1 - 4	104	EQS 2015 - Bioavailable	4.00	ug/l	Till
Zinc	BH1	1 - 4	134	EQS 2015 - Bioavailable	10.9	ug/l	Made Ground Granular / Till
	BH2	1 - 4	177	EQS 2015 - Bioavailable	10.9	ug/l	Till

PAHs

Analyte	Point ID	Response Zone Depth (M)	Result	Criteria Source	Threshold	Units	Stratum
Fluoranthene	BH2	1 - 4	0.027	EQS 2015	0.006	ug/l	Till

Appendix I

CIRIA C552 RISK ASSESSMENT

I RISK APPRAISAL

I.1 RISK APPRAISAL METHODOLOGY

The CSM identifies potential contaminants, receptors and exposure pathways that may be present based on a commercial (CPU) end use.

The identification of potential “contaminant linkages” is a key aspect of the evaluation of potentially contaminated land. An approach based on the UK CIRIA report C552 (Contaminated Land Risk Assessment: A Guide to Good Practice, 2001) has been adopted within this report. For each of the contaminant linkages, an estimate is made of;

- The potential severity of the risk; and
- The likelihood of the risk occurring.

Table 1 presents the classification of the severity of the risk:

TABLE 1 SEVERITY OF RISK

Severe	Acute risks to human health; Major pollution of controlled waters (watercourses or groundwater)
Medium	Chronic (long-term) risk to human health; Pollution of sensitive controlled waters (surface waters or aquifers)
Mild	Pollution of non-sensitive water resources.
Minor	Requirement for protective equipment during site works to mitigate health effects; Damage to non-sensitive ecosystems or species

The probability of the risk occurring is classified by criteria given in Table 2.

TABLE 2 PROBABILITY OF RISK OCCURRING

High Likelihood	Contaminant linkage may be present, and risk is almost certain to occur in the long term, or there is evidence of harm to the receptor.
Likely	Contaminant linkage may be present, and it is probable that the risk will occur over the long term.
Low Likelihood	Contaminant linkage may be present and there is a possibility of the risk occurring, although there is no certainty that it will do so.
Unlikely	Contaminant linkage may be present but the circumstances under which harm would occur are improbable.

An overall evaluation of the level of risk is gained from a comparison of the severity and probability as presented in Table 3.

TABLE 3 COMPARISON OF SEVERITY AND PROBABILITY

		Severity			
		Severe	Medium	Mild	Minor
Probability	High Likelihood	Very high risk	High risk	Moderate risk	Moderate / low risk
	Likely	High risk	Moderate risk	Moderate/ low risk	Low risk
	Low Likelihood	Moderate risk	Moderate/ low risk	Low risk	Very low risk
	Unlikely	Moderate / low risk	Low risk	Very low risk	Very low risk

Table 4 then provides a description of the typical consequences and potential actions required following each risk definition.

TABLE 4 QUALITATIVE RISK ASSESSMENT - CLASSIFICATION OF CONSEQUENCE

Classification	**Definition**
Very High Risk	Severe harm to a receptor may already be occurring, or a high likelihood severe harm will arise to a receptor, unless immediate remedial works / mitigation measures are undertaken.
High Risk	Harm is likely to arise to a receptor, and is likely to be severe, unless appropriate remedial actions / mitigation measures are undertaken. Remedial works may be required in the short-term, but likely to be required over the long-term.
Moderate Risk	Possible that harm could arise to a receptor, but low likelihood that such harm would be severe. Harm is likely to be mild. Some remedial works may be required in the long-term.
Moderate / Low Risk	Possible that harm could arise to a receptor, but where a combination of likelihood and consequence results in a risk that is above low, but is not of sufficient concern to be classified as mild. Limited further investigation may be required to clarify the risk. If necessary, remediation works are likely to be limited in extent.
Low Risk	Possible that harm could arise to a receptor. Such harm, at worst, would normally be mild.
Very Low Risk	Low likelihood that harm could arise to a receptor. Such harm is unlikely to be any worse than mild.

It should be noted that the identification of potential contaminant linkages does not indicate that they are significant. The risk to ground workers during any redevelopment has not been assessed as part of these works. It is recommended that a task specific risk assessment, which may include stipulations with regards to appropriate work control procedures and personal protective equipment (PPE), is completed prior to any future construction works.

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