



**GEO-ENVIRONMENTAL
INVESTIGATION AND
QUANTITATIVE RISK ASSESSMENT**

**LOW MOOR,
CLITHEROE**

320469 – R02 (00)

BOWSALL LIMITED

April 2011

**Safeguarding
your business
environment**

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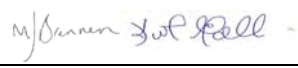
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LOW MOOR, CLITHEROE

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1 INTRODUCTION

RSK STATS Geoconsult Limited (RSK) was requested by Bowsall Limited (Bowsall) to carry out a Preliminary Risk Assessment and Geo-Environmental Ground Investigation and Quantitative Risk Assessment (QRA) for human health and controlled waters at land off Chapel Close, Low Moor, Clitheroe (see Figure 1).

This report presents a factual account of the fieldwork and laboratory testing carried out between January 2011 and March 2011 along with an interpretation of the environmental and geotechnical data to provide geotechnical design information for the proposed redevelopment.

The Preliminary Risk Assessment⁽¹⁾ (PRA) was undertaken by RSK in February 2011. A copy of the report is presented within Appendix B and should be read in conjunction with this report.

1.1 Objective

The objective of the work is to provide sufficient geo-environmental data to support an application for planning permission for a residential development at the site and to further evaluate risks presented within the PRA conceptual site model (CSM). An interpretation of ground conditions is provided to provide the basis for a prospective developer to sensibly evaluate key issues including outline recommendations for foundation design, site re-profiling and infrastructure construction.

1.2 Scope of Works

To meet the objective above the scope of works included:

- The excavation of 10 no. trial pits (TP1 to TP10) using a mechanical excavator at locations across the site shown on Figure 2;
- The drilling of three cable percussion boreholes (BH1 to BH3) to a maximum depth of 10m at locations shown on Figure 2;
- The collection of disturbed and undisturbed soil samples for laboratory contamination and geotechnical testing;
- The installation of three groundwater and ground gas monitoring wells;
- *In situ* geotechnical testing within boreholes using standard penetration tests (SPTs) to provide outline ground condition and geotechnical design information for the proposed redevelopment (foundations and site infrastructure);
- A single round of groundwater monitoring and sampling using bailer methods;
- Four rounds of ground gas monitoring from a scheduled six visits have been undertaken in conjunction with a groundwater sampling event;
- Chemical laboratory analysis of soil and groundwater samples, to test for the presence / absence of organic and inorganic chemicals of potential concern (COPC). BRE suite testing to assess potential risks to building infrastructure was also undertaken; and

- Preparation of a factual and interpretative report including a generic quantitative risk assessment (GQRA) for human health and controlled waters.

1.3 Limitations

The comments given in this report and the opinions expressed are based on review of reports provided to RSK, ground conditions encountered during site works and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigations and therefore could not be taken into account.

This report is subject to the RSK service constraints presented within Appendix A.

2 THE SITE

Information pertaining to the site is outlined within this section. A summary of the previous PRA⁽¹⁾ undertaken by RSK is included for ease of reference, although the original report should be read in conjunction with the current RSK report. The PRA is presented within Appendix B.

2.1 Site Location and Description

The site is approximately 1.8ha in area and currently comprises undeveloped rural land. A public access path, linking into Chapel Close to the southwest, passes through the site from south to north in the west section of the site connecting the adjacent land parcels to the north. Relative to the public access path, the site comprises two land parcels; a larger land parcel located to the east of the path and a smaller land parcel situated to the west.

At the time of the assessment, the site was unoccupied except for a static caravan belonging to the landowner situated on the larger land parcel. The remainder of this land parcel was predominantly open grassland with small area of exposed subsoil in its central portion. A drainage ditch noted to be holding minimal water was located in the southern area of this section of the site and several mature trees were also present along the sites east boundary.

The smaller land parcel also comprised overgrown vegetative cover. A drainage ditch was present in its north section be flowing east to west and discharging into an un-named surface water feature roughly 20m from the northwest site boundary. The Landowner confirmed at the time of the assessment that the drainage ditch was man-made and was constructed to receive land drainage from the larger land parcel to the east.

Low-rise residential housing was located south and west of the site with the River Ribble, approximately 150m further on to the west. Allotment gardens were noted present to the northwest and further agricultural land was situated adjacent to the north and east of the site

The site is at an elevation of approximately 60m above ordnance datum (AOD) and is generally flat for the most part with a sharp incline dropping from east to west in the site's western parcel. The surrounding topography slopes to the west towards the River Ribble. A site plan is presented as Figure 2.

2.2 Site and Surrounding History

The PRA⁽¹⁾ indicates that the site remained undeveloped until 1912 with the exception of a track that passes through the site. In 1912 the site was used as a cricket ground, then in 1932 the western portion of the site was used as allotment gardens and the eastern part was no longer used. The site then remained undeveloped until the present day.

The earliest map extract in 1884 shows the Low Moor Factory to be located roughly 50m southwest of the site and a 'mill race' water channel to run adjacent to the western site boundary feeding the factory with water from the north. Also of note are 2 features labelled 'gasometers' located close to the factory. Residential properties, a school, post office and church occupied the land 60m south of the site with the areas east and north of the site remaining undeveloped. The surrounding area then remained largely unchanged until 1964, with the exception of the construction of a cricket pavilion 20m north west of the site. In 1964 the Low Moor Factory is market as 'depot' which was subsequently demolished in 1971. In 1980 residential development occurred in the area west of the site between the site and the River Ribble. No significant changes are recorded until the present day.

2.3 Previous Reports

The initial conceptual site model (CSM) presented within the RSK PRA⁽¹⁾ identified the following potentially complete pollutant linkages with a risk classification of moderate/low or higher:

- Leaching and vertical migration of potential contaminants from materials within the former landfill parts of the site to groundwater in the underlying Permo-Triassic Secondary A Aquifer;
- Leaching and vertical migration and/or surface run-off of potential contaminants to on-site drainage ditch and adjacent unnamed surface water receptors;
- Permeation of plastic utility pipes by potential contaminants in materials underlying the site resulting in degradation of potable water supply quality;
- Migration of ground gases/vapours from former on site landfill along permeable strata and/or service trenches to surface or future buildings;
- Building foundation attack by potential contaminants on properties proposed in former landfill areas;
- Risks associated with ground gases to new build and adjacent properties arising from landfilled material in western part of site, and from landfill present beyond the site's boundaries;
- Inhalation of ground gases/vapours (associated with historical site uses) by construction workers, future site users and neighbouring residents; and,
- Vapour inhalation of ground gases/vapours from historical off-site sources (landfill extending to north and south of western part of site) by future site users.

3 SITE INVESTIGATION

Intrusive site works were undertaken by RSK between the 31 January and 02 February 2011. Subsequent groundwater sampling and an initial round of ground gas monitoring was undertaken on the 10 February 2011 with three additional ground gas monitoring visits undertaken on the 18 February, 02 March and 17 March 2011. A further two rounds of ground gas monitoring are proposed as part of the ground gas monitoring programme, however consultation with Ribble Valley Council is on-going and additional monitoring events beyond this may be required to satisfy their requirements.

3.1 Investigation Methodology

The intrusive investigation works comprised:

- Three cable percussion boreholes (numbered BH1 to BH3) advanced to depths between 6.25m (BH3) and 10.0m (BH1 & BH2) at locations shown of Figure 2; and
- Ten trial pits (referenced TP1 to TP10) were excavated across the site to depths between 1.8m (TP-10) and 4.0m bgl (TP-5 to TP-7) using a mechanical excavator.

Descriptions of the strata encountered and comments on groundwater conditions are given on the exploratory hole records presented as Appendix C.

3.1.1 Health and Safety Considerations

Site service plans were acquired before commencement of intrusive works. To minimise the likelihood of damage to underground services and risks to site staff, the plans were reviewed and all intrusive investigation locations were scanned using a cable avoidance tool (CAT). As a further precaution hand excavated inspection pits to 1.2m below ground level (bgl) were undertaken prior to commencement of drilling works. As part of RSK's internal health and safety policy, a permit to dig was completed prior to intrusive location and was issued to record the service clearance process.

3.2 Exploratory Location Rationale

The exploratory hole positions were chosen to provide good coverage of the site (where access was possible). The exploratory hole locations are presented within Figure 2. The rationale for the borehole and trial pit locations is given in Table 1.

Table 1: Investigation Location Rationale

Location	Location	Rationale
TP1, TP2 and BH3	West land parcel	To provide geotechnical information and contamination assessment in the area of the former on-site landfill
TP3, TP4 and BH2	Southwest corner of the east land parcel	To assess the extent and type of the fill materials in the former slurry pit and provide geotechnical information in this area
BH1, TP-5 to TP8	East land parcel	Provide geotechnical and contamination information across general site area
TP9	West section of the east land parcel adjacent to the on-site static caravan	Assess potential contaminations issues associated with the buried septic tank and future public open space area
TP-10	Southeast of east land parcel	Investigate historical pond area

3.3 Soil Sampling and Testing

Representative samples were taken throughout the full depth of the intrusive investigation locations (borings and trial pits) and returned to the laboratory for chemical analysis. The descriptions of the strata encountered together with comments on groundwater conditions and hole stability are given in the exploratory hole records presented in Appendix C.

Standard penetration tests (SPTs) were carried out in the boreholes to assess the relative density of the strata within the boreholes. The values of penetration resistance (N values) are given on the borehole records in Appendix C. Hand vane tests were carried out at eight of the trial pit locations where clay was encountered. Below 0.5m tests were performed on large lumps of excavated material to avoid man-entry

Undrained shear strengths from these tests are presented on the trial pit logs in Appendix C.

3.4 Standpipe Installations

Standpipes were installed within the boreholes to permit subsequent monitoring of ground gas and groundwater. Details of the installations are given on the respective records presented in Appendix C. The installations comprised a response zone of perforated pipe (50mm diameter) surrounded by washed gravel. Plain pipe and bentonite seal was placed above the response zone to minimise any downward migration of surface water. Gas monitoring valves were placed in the top of the installations and the installation finished with a lockable metal cover flush with ground level.

3.5 Groundwater Monitoring and Sampling

Groundwater monitoring and sampling of the monitoring wells was undertaken on 10 February 2011. The groundwater samples were recovered using a disposable plastic bailer and placed in containers appropriate to the anticipated testing suite and stored at 4°C to minimise volatilisation. The samples were then transported under chain of custody documentation to the analytical testing laboratory at Envirolab, Hyde.

3.5.1 Ground Gas Monitoring

To characterise the ground gas regime, a minimum of six ground gas monitoring rounds will be completed, over a period of approximately three months targeting a range of atmospheric pressure conditions. To date four monitoring rounds have been undertaken (10 and 18 February 2011 and 02 and 16 March 2011). The results of the two additional monitoring rounds and final interpretation of the ground gas regime will be reported by RSK in a separate addendum report.

The monitoring events utilised an infra-red gas analyser, with the following parameters measured:

- Flow rates (l/hr);
- Methane concentrations (% by volume in air (%v/v));
- Carbon dioxide concentrations (%v/v);
- Oxygen concentrations (%v/v);
- Lower Explosive Limit readings (%); and
- Atmospheric pressure readings (mb).

The monitoring data collected from the site is presented in Appendix D.

3.6 Results

The results of the site investigation works, ground conditions, *in situ* field tests and gas monitoring events completed to date are discussed below, the findings of which were used to inform the scheduling of laboratory analysis.

3.6.1 Ground Conditions

In general, ground conditions beneath the site were consistent with those anticipated from the geological map for the area. Conditions encountered during the investigation are briefly summarised below:

Topsoil: Topsoil was found at all locations between 0.05m and 0.40m thick, to a maximum depth of 0.40m bgl.

Made ground: Made ground was encountered at eight of the 13 intrusive locations across the site to depths between 0.9m (TP4 and BH2) and 2.0m (TP1). In the west of the site (at intrusive locations TP1, TP2, TP3 and BH3) the made ground comprised a fill material of demolition material mixed with sand or clay. Inclusions of tyres, timber, glass, china and plastic were also noted within the made ground materials. The made ground deposits at these locations were encountered to depths of between 1.6m to 2.0m bgl.

At TP-3, a concrete obstruction and land drain were encountered at 2.50m bgl underlying the made ground. Both of these features are likely to be associated with the base of the former slurry pit.

Superficial Geology: The superficial geology generally comprised a soft to firm sandy clay overlying a firm grey/brown slightly sandy CLAY with variable gravel and cobble content. In TP7 (located in east section of the larger land parcel), a firm grey slightly silty clay stratum was encountered from 2.7m bgl to 4.0m bgl (base of deposits not proven). The clay was typically of medium to high strength.

At TP10 a thin band of brown amorphous peat was encountered between 1.0m to 1.1m bgl overlying soft grey sandy CLAY.

The base of the superficial deposits was not proven beyond the base of any of the intrusive locations and was encountered to a maximum depth of 10.0m bgl (BH1 and BH2).

Groundwater: Groundwater within the boreholes (BH1 to BH3) was typically encountered as a continual slow seepage during drilling with no groundwater strikes recorded. Within the trial pits a moderate ingress of groundwater was observed from the west face of TP-2. At TP-10, the surficial soils were noted to be waterlogged and anecdotal evidence from the Landowner at the time of the assessment suggested that a pond had historically been present in this area.

3.6.2 Observed Contamination

An organic odour was noted within the made ground at trial pit location TP3. No other visual or olfactory evidence of contamination was noted during the investigation.

3.6.3 Laboratory Analysis

Soil Analysis

On 07 February 2011, 13 selected soil samples, were submitted to the accredited testing laboratory (EnviroLab) under controlled conditions for UKAS and MCERT laboratory chemical analysis, where applicable.

Soil samples were analysed for a selection of:

- Total petroleum hydrocarbons split into aliphatic and aromatic hydrocarbon bands (spec TPH), benzene, toluene, ethyl benzene and xylene (BTEX);
- Polycyclic aromatic hydrocarbons (PAH);
- Arsenic, cadmium, copper, chromium, chromium hexavalent, lead, mercury, nickel, selenium and zinc;

- Total organic carbon (TOC);
- Asbestos screening; and
- Sulphate and pH.

The rationale for analysis is presented in Table 2.

Table 2: Rationale for Analysis of Soil Samples

Sample	Analysis	Rationale
BH1 0.5-1.0m	Metals, speciated TPH and TOC	Assess for potential shallow contaminants in the made ground materials in the east land parcel
BH1 6.0m	pH & Sulphahte	Assist in foundation design
BH2 2.0m	pH & Sulphahte	
BH3 0.5-1.0m	Metals, Sulphate, speciated TPH, PAHs, Asbestos and TOC	Assess for potential organic and inorganic contaminants associated with made ground materials in the former landfill area
BH3 3.0m	pH & Sulphahte	Assist in foundation design
TP1 1.1m	speciated TPH	Assess for potential organic and inorganic contaminants associated with made ground materials in the former landfill area
TP2 0.6m	Metals, speciated TPH, PAHs, Asbestos and TOC	
TP2 1.8m	speciated TPH and TOC	Assess for potential organic contamination that may have impacted natural strata underlying the former landfill area
TP3 1.5m	Metals, speciated TPH, PAHs and TOC	Assess for potential organic and inorganic contaminants associated with made ground materials in the former slurry pit area
TP5 0.3m	Metals, pH & Sulphahte, PAH and TOC	Assist in foundation design
TP7 2.5m	pH & Sulphahte	Assist in foundation design
TP8 0.1m	Metals and TOC	Assessment of topsoil material
TP9 0.4m	Metals, PAH and TOC	Assess for potential organic and inorganic contaminants in shallow strata in vicinity of septic tank area and proposed public open space area

Details of the analytical methods and limits of analysis are provided on the certificates of analyses, which are presented in Appendix E

Water Analysis

On 10 February 2011, three groundwater samples, were submitted the accredited testing laboratory (EnviroLab) under controlled conditions for UKAS and MCERT laboratory chemical analysis, where applicable.

Water samples were submitted for a selection of:

- Total petroleum hydrocarbons split into aliphatic and aromatic hydrocarbon bands (spec TPH),
- Polycyclic aromatic hydrocarbons (PAH);

- Arsenic, cadmium, copper, chromium, chromium hexavalent, lead, mercury, nickel, selenium and zinc;

Details of the analytical methods and limits of analysis are provided on the certificates of analyses, which are presented in Appendix F.

3.6.4 Ground Gas Regime

A summary of ground gas concentrations recorded at each borehole during the gas monitoring visits completed on 10 and 18 February 2011, and 02 and 16 March 2011 are presented in Table 3. Appendix D should be consulted for the complete records. The atmospheric pressure and observed weather conditions are presented in Table 4.

Two additional are yet to be undertaken, and will include periods of low or falling pressure.

The complete records are presented in Appendix D.

Table 3: Summary of Ground Gas Monitoring Data

Borehole	Minimum Oxygen Concentration (%v/v)	Methane maximum (%v/v)	Maximum Carbon dioxide concentration (%v/v)	Peak Gas Flow Rate (L/hr)	PID (ppm)
BH1	19.4	<0.1	1.0	0	<0.1
BH2	19.4	<0.1	<0.1	-7.2	<0.1
BH3	0.3	6.7	2.2	2.0	<0.1

Table 4: Summary of Atmospheric Conditions

Date	Recorded Atmospheric Pressure (mB)	Atmospheric Pressure (mB) Three Days Prior to Monitoring Event (Taken from Leeds/Bradford at: http://www.wunderground.com/history)			Observed Weather Conditions
		Previous Day	2-days previous	3-Days Previous	
10/02/2011	1007	1013	1019	1006	Sunny and damp underfoot
18/02/2011	1010	1005	993	990	Cool and Overcast
02/03/2011	1038	1038	1039	1032	Cloudy, cool and dry with a slight breeze
17/03/2011	1011	1015	1016	1016	Temperate and dry

3.6.5 Variable Head Permeability Testing

On 31 January and 01 February 2011 variable head permeability tests were undertaken in BH1 and BH3, respectively. Permeability tests facilitate estimation of hydraulic conductivity of the geological strata through which the tests are undertaken. For both boreholes, the tests were undertaken within the natural Glacial Till material. The permeability tests were carried out and calculated in accordance with Section 6.25.4 of BS5930 ⁽²⁾.

In BH1 the permeability test conditions comprised a 150mm diameter borehole cased to 9.0m bgl with the bottom 1.0m (i.e. the test zone) uncased. Following the permeability test a hydraulic conductivity of 5.0×10^{-7} m/sec was calculated.

In BH3 the permeability test conditions comprised a 150mm diameter borehole cased to 5.0m bgl with the bottom 1.2m (i.e. the test zone) uncased. Following the permeability test a hydraulic conductivity of 2.0×10^{-5} m/sec was calculated. This is a slightly higher hydraulic conductivity value than would typically be expected for Glacial Till material. However, the presence of large boulders reported by the driller in BH3 from 4.0m to 6.2m bgl could possibly explain this.

The resting water level parameter used as part of the hydraulic conductivity calculation was taken as the groundwater level recorded during the last groundwater gauging visit on 17 March 2011 because the boreholes were dry during drilling.

The permeability test results are presented as Appendix G.

3.6.6 Groundwater Gauging Data

As part of the ground gas monitoring programme and water sampling event, groundwater levels within in the monitoring wells have been gauged. The information-to-date is presented in the table, below:

Table 5: Groundwater Gauging Data

Date	Depth to Water (m bgl)			
	10/02/2011	18/02/2011	02/03/2011	17/03/2011
BH1	1.534	1.590	1.598	1.616
BH2	0.346	0.753	0.752	0.775
BH3	N/D	0.961	1.100	0.896

N/D – Not Determined due to well headworks being flooded

4 QUANTITATIVE RISK ASSESSMENT

In line with CLR 11⁽³⁾ the laboratory data has been assessed using generic quantitative risk assessment methods (GQRA).

4.1 Conceptual Model

The following potentially complete relevant pollutant linkages were identified during the PRA⁽¹⁾ and are considered potentially complete following the intrusive investigation works:

- Leaching and vertical migration and/or surface run-off of potential contaminants to on-site drainage ditch and adjacent unnamed surface water receptors;
- Permeation of plastic utility pipes by potential contaminants in made ground materials underlying the site resulting in degradation of potable water supply quality;
- Migration of ground gases/vapours from former on site landfills along permeable strata and/or service trenches to surface or future buildings;
- Building foundation attack by potential contaminants on properties proposed in former landfill areas and from the natural ground;
- Risks associated with ground gases to new build and adjacent properties arising from landfilled material in western part of site, from landfill present beyond the site's boundaries;
- Inhalation of ground gases/vapours (associated with historical site uses) by construction workers, future site users and neighbouring residents; and,
- Vapour inhalation of ground gases/vapours from historical off-site sources (landfill extending to north and south of western part of site by future site users.

The following potentially complete relevant pollutant linkage was identified during the PRA but can be considered incomplete following the intrusive investigation work. Justification is given also.

- *Leaching and vertical migration of potential contaminants from materials within the former landfill parts of the site to groundwater in the underlying Permo Triassic Secondary A Aquifer;*

Based on the encountered ground conditions and field testing a significant thickness of low permeability material (i.e. glacial till) exists below the former landfill parts of the site. The Glacial Till deposits were proven to at least 6.2m bgl in BH3 located within the former landfill area and to at least 10.0m bgl in BH1 and BH2. This material has a low vertical hydraulic conductivity and therefore leaching and vertical migration of contaminants from the overlying soils in groundwater in the underlying Secondary A Aquifer is considered highly unlikely.

4.2 Human Health

In line with CLR 11⁽³⁾, the chemical soil and groundwater data were compared with the relevant GAC for the proposed future site usage and that of the surrounding area (residential being the most conservative). The derived GAC for a residential with gardens (also allowing for home grown vegetables) end use are presented in Appendix H and those for water supply pipelines in Appendix I.

4.2.1 Soil

The laboratory chemical testing results for soil were compared against Human Health GACs for residential with gardens end-use. This provided a means to evaluate potential risks associated with direct contact and vapour inhalation pathways. No exceedances of the GACs were recorded within the tested samples.

4.2.2 Water

The laboratory chemical testing results for the groundwater samples were compared against Human Health GACs for residential with gardens end-use. This provided a means to evaluate potential risks associated with direct contact and vapour inhalation pathways. No exceedances of the GACs were recorded within the tested samples.

4.2.3 Water Supply Pipelines

Risks to the water supply of the proposed commercial development have been initially assessed by studying the potential permeation of contaminants through plastic water pipes, in accordance with the Water Regulations Advisory Scheme Information and Guidance Note, October 2002 (5). The guidance outlines threshold levels for certain toxic contaminants, which could affect the selection of pipe materials.

The assessment recorded exceedances of the arsenic threshold of 10mg/kg at three locations, the mercury threshold of 1mg/kg at one location and the total TPH threshold of 50mg/kg at two locations. All exceedances relate to the made ground materials within the former landfill area in the west section of the site except for one of the arsenic exceedances which relates to the topsoil material in TP-8. In addition, exceedance of the upper pH threshold value of 8 was recorded in seven of the tested samples comprising both made ground and natural materials.

Where concentrations of determinands exceed threshold levels, special consideration of material selection for water supply pipelines is required.

Details of the GAC for phytotoxic effects and water supply pipelines are presented in Appendix I.

4.3 Vegetation

Comparison of the laboratory results with GAC values for phytotoxic metals indicates no exceedances within the tested samples.

4.4 Controlled Waters Assessment

Groundwater results have been compared with freshwater Environmental Quality Standards (EQS), where available, owing to the on-site drainage ditch, adjacent unnamed surface water receptors and the nearest significant surface water receptor (River Ribble). In the absence of alkalinity data, for EQS values of determinands that are variable dependent upon groundwater hardness, a hardness range of 150-200mg/l CaCO₃ has been utilised. This hardness range represents a mid-range value relative to typical alkalinity concentrations in groundwater.

It is noted that that an EQS is only available for heavy metals, BTEX and naphthalene, therefore to assess PAH compounds, RSK has initially used the predicted no-effect concentrations (PNEC) included in Environment Agency Publication P45(8). In the absence of an EQS for TPH, the Surface Water Regulations (1996)(9) limit of 0.05mg/l has been used. This is considered reasonable since it is below the sum of the EQS for BTEX compounds (0.13mg/l), which are typically the most mobile and toxic of the petroleum hydrocarbons; and PAH compounds are being considered separately.

Details on the derived GAC for controlled waters are provided in Appendix I.

Concentrations of all analytes were recorded below the Controlled Water GACs in all samples analysed.

4.5 Ground Gas

In order to assess the significance of ground gases at the site, measured concentrations and flow rates have been used to generate gas screening values (GSVs). These are presented in Appendix J. . The ground gas data was assessed using the NHBC Traffic Light classification system⁽⁴⁾ since low-rise residential properties are proposed. This classification system assumes an open ventilated under floor void of at least 150mm. Table 5 presents the GSVs calculated using the data recorded to date.

Table 6: Summary of Ground Gas Monitoring Data

Borehole	Methane maximum (%v/v)	Carbon dioxide maximum (%v/v)	Peak Gas Flow Rate (L/hr)	GSV – CO ₂ (L/hr)	GSV – CH ₄ (L/hr)
BH1	<0.1	1.0	0	0.00	0.00
BH2	<0.1	<0.1	-7.2	0.00	0.00
BH3	6.7	2.2	2.0	0.04	0.13

GSVs of 0.13 l/hr and 0.04 l/hr have been calculated for methane and carbon dioxide, respectively. These result in a NHBC Traffic Light Classification of 'Green' meaning no ground gas mitigation measures are considered necessary. However, given that a registered historical landfill is present on site, is gassing and landfilling operations have also occurred in the former slurry pit area, it would be prudent to increase the classification to Amber 1 and thus ground gas protection measures will be required as part of any future development at the site in the affected areas.

Confirmation of the classification of the ground gas regime and ground gas recommendations at the site will be further assessed following completion of the two remaining monitoring rounds. However, it is important to note that discussions with the regulators are on-going and, given the presence of a historical landfill on-site, additional monitoring events to supplement the remaining ground gas visits may be required to satisfy regulatory requirements

4.6 Chemical Attack on Concrete

Using the soil sulphate concentration and pH the soil was evaluated against the BRE Special Digest 1:2005 Concrete in Aggressive Ground document⁽⁵⁾. The maximum sulphate concentrations measured in Made Ground and natural soils were 60mg/l and 110mg/l respectively and the pH was measured as between 7.2 and 8.6. Hence the recommended concrete design classification is:

- Design sulphate (DS) - DS-1; and
- Aggressive Chemical Environment for Concrete classification: AC-1.

4.7 Refined Conceptual Model

The GQRA has identified the following complete pollutant linkages:

1. Heavy metals and total TPH in shallow made ground materials that could potentially impact on the quality of potable water delivered by plastic water supply pipes.

4.8 Waste Acceptance Assessment

The current UK legislation (the Landfill (England and Wales) Regulations 2005) covering the disposal of wastes to landfill requires the waste producer to fully characterise the waste by adequate chemical testing, so allowing a determination of the landfill category able to accept the waste generated. If the waste is tested but fails to meet the required criteria, then the waste may need to be treated in such a way as to render it acceptable, prior to disposal. The landfill operator should then only accept the waste if it has adequately been tested and characterised.

The waste should then be periodically checked to ensure that these parameters have not changed (this may not be required, depending on the quantity of waste) and should be checked at the landfill to verify that it is the expected waste.

The information obtained from the initial characterisation provides the basis for compliance with the Duty of Care requirements given in the Landfill Regulations (2005) and allows an assessment of opportunities for reuse, treatment or disposal of any waste including testing for waste acceptance to landfill. If the basic characterisation of the waste shows that the waste fulfils the criteria for a landfill class, the waste is deemed to be acceptable at this class of landfill. If this is not the case, the waste is not acceptable at this class of landfill.

RSK has developed a waste soils characterisation assessment tool, which follows the guidance within WM2. The analytical results have been run through this assessment tool for potential off-site disposal of materials in the future and the material has been classified as **non-hazardous**. Any material proposed for off-site disposal during future works should therefore should be disposed of at a suitably licensed non-hazardous waste landfill. However, RSK would draw attention to the fact that during the intrusive works several tyres were encountered within the areas on site that have been subject to historically infilling operations. If materials from these areas are designated for off-site disposal then RSK would recommend that screening for and removal of tyres from this material be undertaken because current legislation does not permit disposal of tyres to landfill.

A copy of the Waste Classification Assessment is included in Appendix L.

5 INITIAL GEOTECHNICAL ASSESSMENT

This section of the report discusses potential issues for foundations at the site arising from the ground investigation. The information herein is written to allow a prospective developer to sensibly evaluate key issues. All comments below are based on depths relating to existing ground level at the time of the investigation.

Natural Ground: Site Excepting Former Landfill Areas

Over most of the site made ground is absent. The natural clay beneath the majority of the site is likely to provide a suitable foundation strata subject to the comments below.

Beneath much of the site (excluding the former landfilled areas) there is a notable layer of softer sandier clay beneath the topsoil, which typically extends to about 1.5m to 1.80m bgl although there are variations from this. In places granular soils comprising sands with gravels (TP6) and very sandy clays (TP5 and TP10), probably borderline granular/cohesive are present. This material typically exhibits high plasticity and the cohesive soils show undrained shear strengths of between 35 kN/m² and 113 kN/m². The latter result does not appear typical for these very shallow soils, which were identified to be generally saturated. The presence of these soils to <2m depth is notable in the south and east part of the site, they appear thinner elsewhere.

It would appear that for the most part the upper 1.5m of soil is generally of low to medium strength and contains a greater proportion of granular material, probably resulting in the layer becoming more saturated and softened compared to the less permeable material beneath.

Taking this into account, an estimated nett allowable bearing pressure for preliminary design purposes for the soft shallow natural clays (typically <1.5m) to 1.8m is about 60kN/m² for shallow strip footings.

It would be prudent to take foundations deeper than the shallow soft clays to benefit from the stronger glacial till clays typically deeper than 1.5m bgl. A nett allowable bearing pressure of 130kN/m² for preliminary design purposes.

It would also be prudent to incorporate nominal top and bottom mesh reinforcement within foundations constructed onto the clay to limit any minor differential effects associated with the more granular materials identified locally, particularly if foundations are placed within the upper 1.5m.

In TP10 a 0.1m layer of peat was present. This was not identified elsewhere. In addition, the soft very sandy clay at this location extended to 1.8m (base unproven). Foundations in this part of the site should be piled.

Former Landfill Area

Made ground associated with the former landfill extends to between 1.6m and 2.0m in the smaller land parcel to the west and to 1.8m in the south west corner of the main site.

Generally made ground is not recommended as a foundation formation due to variability, the presence of hard points such as large concrete fragments, potential for excessive settlement, and the potential for voids formed due to bridging of larger fragments (oversize materials such as intact or partially intact old foundations and concrete). Under certain circumstances it may be suitable for ground improvement and a specialist ground improvement contractor should be consulted for suitability of the site and the materials for such measures.

However, at this site evidence of a tyre in TP1, and timber and plastic amongst other material in the made ground elsewhere indicates that the material placed in this part of the site does not solely comprise granular demolition materials. Such deleterious material precludes founding in this material and it is recommended that foundations are taken down to the natural clay.

It is recommended that these made ground soils are dug over and sorted such that such deleterious material is removed prior to recompaction, however this may prove impracticable.

Ground improvement is considered an unlikely option given the presence of the deleterious material, however if this is considered the only potentially economic solution, then a specialist contractor should be consulted, and preferably allowed to undertake their own inspection of the ground.

Whilst ground improvement techniques such as stone columns are considered unlikely to act as a significant migration pathway resulting potential risk to surface waters, the presence of hazardous ground gases should be considered as these may enhance gas migration. Gas protection measures should be considered taking into account the proposed foundation solution. A foundation works risk assessment will be required.

General Comment

There are a number of general issues that should be taken into account when designing foundations.

Water was not significantly encountered in the natural clays and appears predominantly to be present in the sandier softer clays within the upper 1.5m to 1.8m. It is unlikely such water will require significant effort to control for construction works.

There are trees present along and within the eastern boundary of the site. The modified plasticity index indicates that the shallow clays typically exhibit moderate volume change potential and are shrinkable soils. Consideration should be given in design for shrinkage and heave of these clays, which appear saturated in situ due to infiltration. On completion of the development infiltration will be significantly less than current and thus there may be a resultant reduction in moisture content leading to shrinkage. Foundation depths in the vicinity of trees, whether present or to be planted, should be in accordance with NHBC Guidance (Standards Chapter 4.2).

6 CONCLUSIONS AND RECOMMENDATIONS

The intrusive investigation encountered Made Ground materials between depths of 0.15m to 2.0m bgl. A significant thickness of Made Ground material was encountered at those locations that were advanced through areas where landfilling operations were known to have occurred historically (i.e. TP1, TP2, TP3 and BH3). At these locations the Made Ground materials were noted to comprise fill material typically comprising demolition material mixed with sand or clay with inclusions of rubber tyres, timber, glass, china and plastic. The surface and very shallow soils across the remainder of the site comprised a layer of grass-covered Topsoil typically 0.2m in thickness.

The superficial geology was encountered at all intrusive locations and generally comprised soft to firm sandy clay overlying firm grey/brown slightly sandy clay with variable gravel and cobble content. In TP7 (located in east section of the larger land parcel) a firm grey slightly silty CLAY stratum was encountered from 2.7m bgl to 4.0m bgl. At TP10 a thin band of brown amorphous peat was encountered between 1.0m to 1.1m bgl overlying soft grey sandy CLAY.

Groundwater was noted as a continual seepage during drilling of the boreholes (BH1 to BH3). In addition, a moderate ingress of water was noted at 1.50m bgl near the base of the made ground deposits in TP2. During the subsequent monitoring visits, groundwater levels have ranged between 0.35m bgl (BH2) and 1.62m bgl (BH1) within the wells.

Ground gas monitoring to date recorded a maximum methane concentration of 6.7%v/v and a maximum carbon dioxide concentration of 2.2%v/v both in BH3. Depleted oxygen concentrations have also been continually encountered at this location with a minimum concentration of 0.3% v/v recorded. A peak flow rate of -7.2l/hr has been recorded to date at BH2. GSVs of 0.13 l/hr and 0.04 l/hr have been calculated for methane and carbon dioxide, respectively. These result in a NHBC Traffic Light Classification of 'Green' meaning no ground gas mitigation measures are considered necessary. However, given that a registered historical landfill is present on site, is gassing and landfilling operations have also occurred in the former slurry pit area, it is would be prudent to increase the classification to Amber 1 and thus ground gas protection measures will be required as part of any future development at the site in the affected areas. Classification of the site's ground gas regime will be confirmed once the additional monitoring has been completed.

No exceedances of the Human Health GAC for a low-rise residential development with private gardens were recorded within the tested samples. Although the GQRA has not identified complete pollutant linkages for potential risks to human health of the end-users, if the fill materials associated with the historic landfill and former slurry pit are to remain *in situ* (subject to geotechnical considerations), then some consideration should still be given to the required thickness of clean cover soil in private gardens and landscaping which are situated above these areas. The natural clays found elsewhere beneath the site would likely prove a suitable material for forming the cover system and, depending on quantities, it may be possible to source this material from foundation excavations.

Comparison of the laboratory results with GAC values for phytotoxic metals indicated no exceedances within the tested samples. Thus, no mitigation measures are required to protect vegetation from these contaminants.

As part of the Controlled Waters Risk Assessment, the chemical test results on the groundwater samples from retrieved from BH1, BH2 and BH3 were compared to existing Environmental Quality Standards, where available. This indicated that concentrations of contaminants within groundwater underlying the site pose minimal risk to the identified on-site un-named surface water receptors and the River Ribble located roughly 95m to the west. Thus, no mitigation measures are required to protect groundwater.

The GQRA has identified the following complete pollutant linkage that require mitigation measures to be incorporated into the development:

1. Heavy metals and total TPH in shallow made ground materials that could potentially impact on the quality of potable water delivered by plastic water supply pipes.

The risk posed by the above can be mitigated through the selection of appropriate pipe material during the design phase of any proposed development.

Re-use of material at the site should be subject to the provisions of a Materials Management Plan.

Over the area of natural ground (excepting the former land fill areas) an allowable bearing pressures for preliminary design purposes should be 60 kN/m² for the soft clay and 130 kN/m² for the underlying firm to stiff glacial till. At one location soft soils and a thin layer of peat were present and in this location a piled foundation solution is recommended. Over the landfill areas foundations cannot be supported within the made ground and should be taken down onto the underlying natural clay soils.

7 REFERENCES

1. RSK Preliminary Risk Assessment Report, Land Off Chapel Close, Low Moor, Clitheroe, RSK Report Reference 320469-R01 (00), February 2011
2. BS5930: 1999 Code of Practice for Site Investigations (incorporating Amendment No 2) 1999 BSI
3. Environment Agency. Model Procedures for the Management of Contaminated Land. Contaminated Land Report Number 11 (CLR11). September 2004.
4. NHBC. Guidance on Evaluation of Development Proposals on Sites where Methane and Carbon Dioxide are Present. March 2007. Report Edition 4
5. Concrete in Aggressive Ground, Special Digest 1:2005, BRE Construction Division, 2005

FIGURES



Reproduced from the 1991 Ordnance Survey 1:50,000 Scale Landranger Map 103 SGR – SD 724 423
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RSK STATS Group Limited, 18 Frogmore Road, Hemel Hempstead, Hertfordshire, HP3 9RT.

SITE LOCATION MAP



LEGEND:

TP1 Trial Pit Locations (31.01.2011)

BH3 Cable Tool Locations (31.01.2011)

A	04.01.11	First Issue	AMC	KH	KH
Rev.	Date	Amendment	Drawn	Chkd.	Appd.



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Client

BOWSALL LTD

Project Title

LOW MOOR,
CLITHEROE

Drawing Title

SITE FEATURES PLAN

Drawn	Date	Checked	Date	Approved	Date
AMC	04.01.11	LC	04.01.11	GS	04.01.11

Scale	Orig Size	Dimensions
NTS	A3	-

Project No.	Drawing File
320469-R02(00)	320469-R02(00)D002A.dwg

Drawing No.	Rev.
FIGURE 2	A

APPENDIX A

RSK Service Constraints

RSK STATS GEOCONSULT LIMITED

SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK STATS Geoconsult Limited (RSK) for Bowsall Ltd, (the "client") in accordance with the terms of a contract between RSK and the "client". The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.
2. Other than that expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.
3. Unless otherwise agreed the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.
4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date hereof, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.
5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.
6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the content between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials.
7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a walkover survey of the site together with RSK's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The Services are also based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely. The Services clearly are limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the walkover survey. Further RSK was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services. RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.
8. The phase II or intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined borehole and soil vapour locations based on the operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information,] and it should not be inferred that other chemical species are not present.
9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site.

APPENDIX B

RSK Preliminary Risk Assessment Report (320469-R01(00))

APPENDIX C

Exploratory Hole Records

Contract: Low Moor, Clitheroe			Client: Bowsall Ltd		Borehole: BH1
Contract Ref: 320469	Start: 31.01.11 End: 31.01.11	Ground Level (): ---	Co-ordinates: ---	Sheet: 1 of 2	

Samples and In-situ Tests				Water	Backfill & Instrumentation	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						Grass covered TOPSOIL	0.40	
0.50-1.00	1	ES				(Soft) orange/brown sandy CLAY with some fine to coarse subangular to subrounded gravel	(0.60)	
0.50-1.00	1	B						
0.50		PID	0.0ppm				1.00	
1.00	2	ES				Grey slightly clayey slightly silty medium to coarse SAND with some fine to coarse subrounded gravel and pockets of clay	1.20	
1.00		PID	0.0ppm					
1.10	2	D				(Firm) reddish brown slightly sandy CLAY with a little fine to coarse subangular to subrounded gravel	(0.60)	
1.20-1.65	3	SPT	N=14					
1.20-1.65	4	B					1.80	
1.80-2.00	3	ES				(Firm) grey/brown slightly sandy slightly silty CLAY		
1.80	5	D						
1.80		PID	0.0ppm					
2.00-2.50	6	U ₍₁₀₀₎	29 blows					
2.50	7	D				... becoming sandy with a little fine to coarse subangular to subrounded gravel from 2.45m	(2.00)	
2.80	8	D				... thin laminae with silt in between, pockets of fine sand/silt and no gravel from 2.80m		
3.00-3.45	9	SPT	N=10					
3.00-3.45	10	B					3.80	
3.80	11	D				(Firm) grey/brown slightly sandy CLAY with much fine to coarse subangular to subrounded gravel		
4.00-4.50	12	U ₍₁₀₀₎	47 blows					
4.00	4	ES						
4.00		PID	0.0ppm					
4.50	13	D				... some gravel at 4.50m		
4.80	14	D						
5.00-5.45	15	SPT	N=14					
5.00-5.45	16	B						
6.00	17	D						
6.00	5	ES						
6.00		PID	0.0ppm					
6.50-7.00	18	U ₍₁₀₀₎	41 blows				(6.20)	
7.00	19	D						
7.50	20	D						
8.00	6	ES						
8.00-8.45	21	SPT	N=17					
8.00-8.45	22	B						
8.00		PID	0.0ppm					

Boring Progress and Water Observations						Chiselling			General Remarks
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth	From	To	Duration (hh:mm)	
									1. Continual slow water seepage 2. Borehole cased with 150mm casing to 9.5m 3. Permeability test undertaken from 9.0m to 10.0m 4. Borehole backfilled with arisings
Method Used: Cable percussion						Plant Used: Dando 2000			All dimensions in metres Scale: 1:50
Drilled By: J Moss						Logged By: KHall			Checked By: 

BOREHOLE LOG

Contract: Low Moor, Clitheroe		Client: Bowsall Ltd		Borehole: BH1
Contract Ref: 320469	Start: 31.01.11 End: 31.01.11	Ground Level (): ---	Co-ordinates: ---	Sheet: 2 of 2

Samples and In-situ Tests				Water	Backfill & Instrumentation	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
9.00	23	D	46 blows			(Firm) grey/brown slightly sandy CLAY with much fine to coarse subangular to subrounded gravel <i>(stratum text copied from layer at 3.80m depth from previous sheet)</i>		
9.50-10.00	24	U ₍₁₀₀₎						
10.00 10.00 10.00	25 7	D ES PID	0.0ppm			Borehole terminated at 10.0m bgl	10.00	

Boring Progress and Water Observations						Chiselling			General Remarks				
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth	From	To	Duration (hh:mm)					
									All dimensions in metres Scale: 1:50				
Method Used:	Cable percussion		Plant Used:	Dando 2000		Drilled By:	J Moss					Logged By:	KHall

Contract: Low Moor, Clitheroe			Client: Bowsall Ltd		Borehole: BH2
Contract Ref: 320469	Start: 31.01.11 End: 01.02.11	Ground Level (): ---	Co-ordinates: ---	Sheet: 1 of 2	

Samples and In-situ Tests				Water	Backfill & Instrumentation	Description of Strata	Depth (Thickness)	Material Graphic Legend	
Depth	No	Type	Results						
						Grass covered TOPSOIL	0.20		
						MADE GROUND comprising (soft) brown sandy CLAY with much gravel of brick, plastic, concrete and natural lithic material	(0.70)		
0.50-0.90	1	ES	0.0ppm				0.90		
0.50-0.90	1	B							
0.50		PID							
1.00	2	ES	0.0ppm 57 blows N=11 0.0ppm			(Firm) brown/grey slightly sandy slightly silty CLAY	(3.00)		
1.00	2	D							
1.00		PID							
1.20-1.70	3	U ₍₁₀₀₎							
1.70	4	D							
1.80	5	D							
2.00	3	ES							
2.00-2.45	6	SPT							
2.00-2.45	7	B							
2.00		PID							
2.80	8	D	34 blows			... becoming sandy at 2.80m			
3.00-3.50	9	U ₍₁₀₀₎							
3.50	10	D							
3.90	11	D	N=18			(Firm) grey/brown slightly sandy CLAY with some fine to coarse subangular to subrounded gravel			
4.00-4.45	12	SPT							
4.00-4.45	13	B							
4.80	14	D	0.0ppm N=32						
4.80	4	ES							
4.80		PID							
5.00-5.45	15	SPT							
5.00-5.45	16	B							
6.00	17	D	N=18			... a little fine subrounded gravel from 6.00m			
6.50-6.95	18	SPT							
6.50-6.95	19	B							
						... much fine to coarse subangular to subrounded gravel from 6.50m	(6.10)		
7.50	20	D							
7.50	5	ES							
7.50		PID	0.0ppm						
8.00-8.45	21	SPT	N=30						
8.00-8.45	22	B				... a little fine subangular gravel from 9.00m			

Boring Progress and Water Observations						Chiselling			General Remarks
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth	From	To	Duration (hh:mm)	
									1. Continual slow water seepage 2. Borehole cased with 150mm casing to 9.5m
Method Used: Cable percussion						All dimensions in metres			Scale: 1:50
Plant Used: Dando 2000			Drilled By: J Moss			Logged By: KHall		Checked By:	

BOREHOLE LOG

Contract: Low Moor, Clitheroe		Client: Bowsall Ltd		Borehole: BH2
Contract Ref: 320469	Start: 31.01.11 End: 01.02.11	Ground Level (): ---	Co-ordinates: ---	Sheet: 2 of 2

Samples and In-situ Tests				Water	Backfill & Instrumentation	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
9.00	23	D				(Firm) grey/brown slightly sandy CLAY with some fine to coarse subangular to subrounded gravel <i>(stratum text copied from layer at 3.90m depth from previous sheet)</i>		
9.50-9.88	24	SPT	N:50 for 225mm				. . . sandy with much gravel from 9.50m	
Borehole terminated at 10.0m bgl								

Boring Progress and Water Observations						Chiselling			General Remarks	
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth	From	To	Duration (hh:mm)		
									All dimensions in metres	
Method Used:			Plant Used:			Drilled By:			Logged By:	
Cable percussion			Dando 2000			J Moss			KHall	
									Checked By:	
									 AGS	

Contract: Low Moor, Clitheroe			Client: Bowsall Ltd		Borehole: BH3
Contract Ref: 320469	Start: 01.02.11 End: 01.02.11	Ground Level (): ---	Co-ordinates: ---		Sheet: 1 of 1

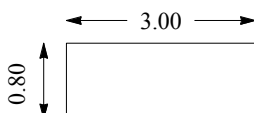
Samples and In-situ Tests				Water	Backfill & Instrumentation	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
0.50-1.00	1	ES				Grass covered TOPSOIL	0.20	
0.50-1.00	1	B				MADE GROUND comprising (soft) brown medium strength sandy CLAY with some to much gravel of brick, concrete, timber, glass and natural lithic fragments		
0.50		PID	0.0ppm				(1.40)	
1.20-1.70	2	U ₍₁₀₀₎	34 blows				1.60	
1.70	2	ES				(Firm) brown/grey slightly sandy CLAY with some fine to coarse subangular to subrounded gravel (driller reports cobbles throughout).		
1.70	3	D						
1.70		PID	0.0ppm					
1.80	4	D						
2.00-2.45	5	SPT	N=18					
2.00-2.45	6	B						
2.80	7	D						
3.00	3	ES						
3.00-3.45	8	SPT	N=22					
3.00-3.45	9	B						
3.00		PID	0.0ppm				(4.60)	
4.00	10	B				... driller reports boulders at 4.00m		
4.80	11	D						
5.00	4	ES						
5.00-5.45	12	SPT	N=20					
5.00-5.45	13	B						
5.00		PID	0.0ppm					
							6.20	
						Borehole terminated at 6.20m bgl, driller reports large boulder obstruction		

Boring Progress and Water Observations						Chiselling			General Remarks
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth	From	To	Duration (hh:mm)	
									1. Driller reports cobbles throughout 2. Continual slow water seepage 3. Borehole cased using 150mm casing to 6.20m 4. Permeability test undertaken from 5.0m to 6.2m
Method Used: Cable percussion						Plant Used: Dando 2000			All dimensions in metres
Drilled By: J Moss						Logged By: KHall			Scale: 1:50
Checked By: AGS									

Contract: Low Moor, Clitheroe		Client: Bowsall Ltd		Trialpit: TP1
Contract Ref: 320469	Date: 31.01.11	Ground Level (): ---	Co-ordinates: ---	Sheet: 1 of 1

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
0.05 0.05	ES1	ES PID	0.0ppm			Grass covered TOPSOIL	0.05	
						MADE GROUND comprising dark brown slightly sandy CLAY fill material with much angular to subangular fine to coarse gravel of brick, concrete, glass, china, timber and plastic	(0.30)	
0.30 0.30	ES2	ES PID	0.0ppm				0.35	
0.40 0.40	ES3	ES PID	0.0ppm			MADE GROUND comprising black slightly clayey coarse SAND fill with much angular fine to coarse gravel of brick, glass, concrete, wire, timber and plastic	(0.65)	
							1.00	
1.00 1.10 1.10	ES4	V ES PID	$c_u=70/68/30$ 0.0ppm			MADE GROUND comprising (soft) brown/grey low to medium strength sandy CLAY with much fine to coarse subangular gravel of brick, concrete and natural lithic material		
1.30 1.30	ES5	ES PID	0.0ppm			... tyre noted at 1.50m	(1.00)	
							2.00	
2.20		V	$c_u=140/150/78$			(Firm) light brown/grey high strength slightly sandy CLAY with some fine to coarse subangular to subrounded gravel and weak mudstone fragments		
						... very stiff, very gravelly blocky clay with a few subangular cobbles between 2.30m and 2.90m		
						... hand vane attempted at 3.00m but material too blocky		
						... very cobbly from 3.00m. Excavator struggling to excavate beyond cobbles from 3.50m	(1.70)	
3.30-3.50 3.30 3.30	1 ES6	B ES PID	0.0ppm				3.70	
						Trial Pit terminated at 3.70m due to slow progress		

Plan (Not to Scale)



General Remarks

1. Trial pit remained stable throughout excavation
2. Trial pit terminated at 3.70m bgl due to slow progress
3. Trial pit backfilled with arisings

All dimensions in metres

Scale: **1:25**

Method Used:

Machine dug

Plant Used:

JCB-3CX

Logged By:

KHall

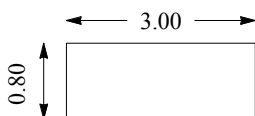
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Contract: Low Moor, Clitheroe		Client: Bowsall Ltd		Trialpit: TP2
Contract Ref: 320469	Date: 31.01.11	Ground Level (): ---	Co-ordinates: ---	Sheet: 1 of 1

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
0.05	ES1	ES PID	0.0ppm			Grass covered TOPSOIL	0.05	
0.05								
0.20	ES2	ES PID	0.0ppm			MADE GROUND comprising dark brown slightly sandy CLAY fill material with much gravel of brick, concrete, glass, china, timber and plastic	(0.35)	
0.20							0.40	
0.60	ES3	ES PID	0.0ppm			MADE GROUND comprising black very clayey coarse SAND fill with much fine to coarse subangular to angular gravel of brick, glass, concrete, wire, timber, plastic and breeze block		
0.60								
						... spalling along south face of trial pit from 1.00m to 1.70m	(1.30)	
						... water ingress at 1.50m from west face of trial pit		
						... large stone flags and concrete at 1.50m	1.70	
1.80	ES4	ES PID	0.0ppm			(Firm) light brown/grey slightly sandy CLAY with some fine to coarse subangular to subrounded gravel		
1.80								
						... cobbles of mudstone from 2.30m	(1.20)	
2.50	ES5	ES PID	0.0ppm					
2.50							2.90	
						Trial Pit terminated at 2.90m due to slow progress		

Plan (Not to Scale)



General Remarks

- Spalling in south face of trail pit from 1.0m to 1.7m
- Trial pit backfilled with arisings

All dimensions in metres

Scale: **1:25**

Method Used:

Machine dug

Plant Used:

JCB-3CX

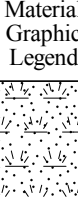
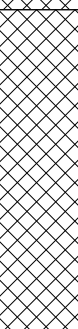
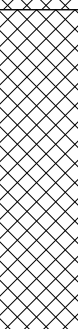
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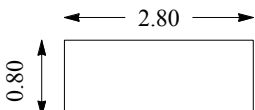
KHall

Checked By:



Contract: Low Moor, Clitheroe		Client: Bowsall Ltd		Trialpit: TP3
Contract Ref: 320469	Date: 31.01.11	Ground Level (): ---	Co-ordinates: ---	Sheet: 1 of 1

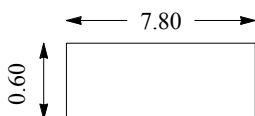
Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
0.20 0.20	ES1	ES PID	0.0ppm			Grass covered TOPSOIL with black bin bags, plastic and bricks	(0.40) 0.40	
0.50 0.50	ES2	ES PID	0.0ppm			MADE GROUND comprising (friable) grey slightly sandy CLAY with much subangular fine to coarse gravel of brick, mudstone and concrete	(0.30) 0.70	
0.70		V	$c_u=78/100/96$			MADE GROUND comprising (firm) black/grey high strength slightly sandy CLAY with much gravel of brick, concrete, breeze block, rotting timber, sandstone and plastic		
1.00 1.00	ES3	ES PID	0.0ppm				(1.10)	
1.50 1.50	ES4	ES PID	0.0ppm			. . . very sandy clay material in east face of pit and slight organic odour at 1.50m	1.80	
2.00		V	$c_u=102/142/172$			(Firm) grey/brown high strength sandy CLAY with some fine to coarse subangular to subrounded gravel	(0.70)	
2.50 2.50	ES5	ES PID	0.0ppm			. . . land drain in central base of pit at 2.50m . . . concrete in south section of pit at 2.50m . . . machine operator reports obstruction at 2.50m Trial pit terminated at 2.50m	2.50	

Plan (Not to Scale) 		General Remarks					
		1. Walls of trial pit remained stable throughout excavation 2. Concrete base and land drain encountered at 2.5m in base of pit (possibly associated with historical slurry pit) 3. Trial pit backfilled with arisings					
		All dimensions in metres		Scale: 1:25			
Method Used:	Machine dug	Plant Used:	JCB-3CX	Logged By:	KHall	Checked By:	AGS

Contract: Low Moor, Clitheroe		Client: Bowsall Ltd		Trialpit: TP4
Contract Ref: 320469	Date: 31.01.11	Ground Level (): ---	Co-ordinates: ---	Sheet: 1 of 1

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
0.50 0.50	ES1	ES PID	0.0ppm			Grass covered TOPSOIL MADE GROUND comprising (friable) grey slightly sandy CLAY with much subangular fine to coarse gravel of brick, mudstone and concrete MADE GROUND comprising (firm) black/grey slightly sandy CLAY with much gravel of brick, concrete, breeze block, rotting timber, sandstone and plastic	0.05 0.20 (0.70)	
1.00 1.00	ES2	ES PID	0.0ppm			(Firm) light brown sandy CLAY with a little fine subangular gravel and occasional partings of fine orange sand	0.90 (0.40) 1.30	
1.40 1.40 1.40	ES3	ES V PID	$c_u=104/116/100$ 0.0ppm			(Firm) brown high strength slightly sandy CLAY with some fine to coarse subrounded to subangular gravel	(0.70) 2.00	
Trial pit terminated at 2.00m								

Plan (Not to Scale)



General Remarks

1. Trial pit remained stable throughout excavation
2. Trial pit excavated as trench to determine location edge of fill material in adjacent historical slurry pit located in southeast corner
3. Trial pit backfilled with arisings

All dimensions in metres

Scale: **1:25**

Method Used:

Machine dug

Plant Used:

JCB-3CX

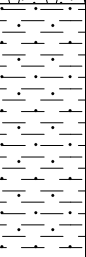
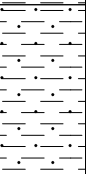
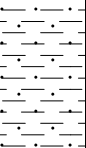
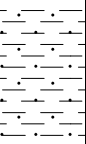
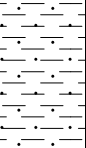
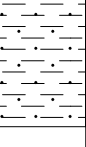
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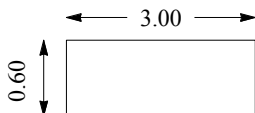
KHall

Checked By:

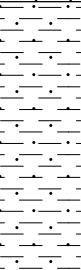
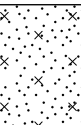
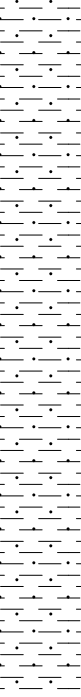


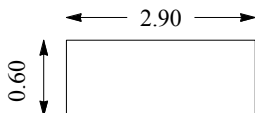
Contract: Low Moor, Clitheroe		Client: Bowsall Ltd		Trialpit: TP5
Contract Ref: 320469	Date: 31.01.11	Ground Level (): ---	Co-ordinates: ---	Sheet: 1 of 1

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thick ness)	Material Graphic Legend
Depth	No	Type	Results					
						Grass covered TOPSOIL	0.25	
0.20 0.20 0.30 0.30	ES1 ES2	ES PID ES PID	0.0ppm 0.0ppm			(Soft) brownish/orange low to medium strength very sandy CLAY with a little fine subangular gravel	(0.85)	
0.70		V	c _u =30/28/46				1.10	
1.20	1	B				(Soft) grey very sandy CLAY with much subangular to subrounded fine to coarse gravel (wet)	(0.60)	
							1.70	
1.80 1.80 1.80	ES3	ES V PID	c _u =100/128/80 0.0ppm			(Soft) reddish brown/grey high strength slightly sandy CLAY with pockets of fine to medium grey sand		
						... becoming (firm) from 2.00m		
						... thin laminae (<2mm) from 2.40m		
2.60		V	c _u =164/138/140				(2.30)	
3.20 3.20	ES4	ES PID	0.0ppm					
3.80		V	c _u =104/104/100				4.00	
						Trial pit terminated at 4.00m		

Plan (Not to Scale)		General Remarks		
		1. Faces of trial pit remained stable throughout excavation 2. Trial pit backfilled with arisings		
Method Used: Machine dug		Plant Used: JCB-3CX	Logged By: KHall	Checked By: AGS
All dimensions in metres		Scale: 1:25		

Contract:	Low Moor, Clitheroe		Client:	Bowsall Ltd		Trialpit:	TP6	
Contract Ref:	320469		Date:	31.01.11		Ground Level ():	---	
						Co-ordinates:	---	
						Sheet:	1 of 1	

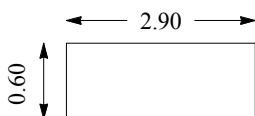
Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						Grass covered TOPSOIL	0.20	
						(Soft) brownish/orange very sandy CLAY with a little fine subangular gravel	(0.90)	
							1.10	
1.20 1.20 1.20	1 ES1	B ES PID	0.0ppm			Grey slightly silty medium to coarse SAND with much fine to coarse subrounded gravel (saturated)	(0.40)	
1.60		V	$c_u=104/120/100$			(Firm) grey high strength slightly sandy CLAY with a little medium subrounded gravel	1.50	
2.50 2.60	2	B V	$c_u=132/88/104$				(2.50)	
3.00 3.00 3.00	ES2	ES V PID	$c_u=100/122/90$ 0.0ppm					
							4.00	
						Trial pit terminated at 4.00m		

Plan (Not to Scale)		General Remarks	
		1. Trial pit remained stable throughout excavation 2. Trial pit backfilled with arisings	
All dimensions in metres		Scale:	1:25
Method Used:	Machine dug	Plant Used:	JCB-3CX
		Logged By:	KHall
		Checked By:	
			

Contract: Low Moor, Clitheroe		Client: Bowsall Ltd		Trialpit: TP7
Contract Ref: 320469	Date: 31.01.11	Ground Level (): ---	Co-ordinates: ---	Sheet: 1 of 1

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						Grass covered TOPSOIL	0.15	
						(Soft) brownish/orange very sandy CLAY with a little fine subangular gravel	(0.85)	
						Grey slightly silty medium to coarse SAND with much fine to coarse subrounded gravel (saturated)	1.00	
						(Firm) grey high strength slightly sandy CLAY with pockets of fine to medium grey sand	(0.50)	
						... becoming reddish brown from 2.00m	1.50	
1.60		V	$c_u=96/100/74$			... very stiff, high to very high strength from 2.40m	(1.20)	
2.40	ES1	V	$c_u=144/200/220$			(Firm) grey generally medium to high strength laminated slightly silty CLAY	2.70	
2.50		ES PID	0.0ppm					
2.50								
2.80		V	$c_u=104/60/70$					
3.00	ES2	ES PID	0.0ppm					
3.00								
3.60	1	B					(1.30)	
4.00		V	$c_u=68/78/72$			Trial pit terminated at 4.00m	4.00	

Plan (Not to Scale)



General Remarks

1. Trial pit remained stable throughout excavation
2. Trial pit backfilled with arisings

All dimensions in metres

Scale: **1:25**

Method Used:

Machine dug

Plant Used:

JCB-3CX

Logged By:

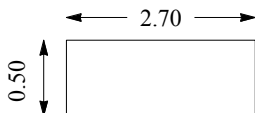
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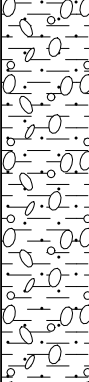


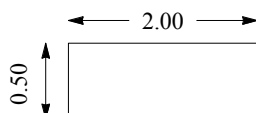
Contract: Low Moor, Clitheroe		Client: Bowsall Ltd		Trialpit: TP8
Contract Ref: 320469	Date: 31.01.11	Ground Level (): ---	Co-ordinates: ---	Sheet: 1 of 1

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
0.10 0.10	ES1	ES PID	0.0ppm			Grass covered TOPSOIL	0.20	
						(Soft) brownish/orange very sandy CLAY with a little fine subangular gravel	(0.60)	
							0.80	
1.00		V	$c_u=90/70/78$			(Firm) grey high strength slightly sandy CLAY with some to much fine to medium to coarse subangular to subrounded gravel and many cobbles of mudstone, slate and limestone		
1.30 1.30	ES2	ES PID	0.0ppm			... very blocky from 1.20m		
1.50-2.00	1	B				... occasional boulders from 1.50m	(1.80)	
2.50	2	B					2.60	
						Trial pit terminated due to slow progress through cobbles/boulders		

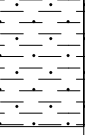
Plan (Not to Scale)		General Remarks		
		1. Trial pit remained stable throughout excavation 2. Trial pit backfilled with arisings		
All dimensions in metres		Scale: 1:25		
Method Used: Machine dug	Plant Used: JCB-3CX	Logged By: KHall	Checked By:	

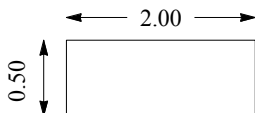
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Contract Ref:	320469		Date:	31.01.11		Ground Level ():	---	
						Co-ordinates:	---	
						Sheet:	1 of 1	

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
0.40	ES1	ES PID V	0.0ppm $c_u=90/120/128$			Grass covered TOPSOIL	0.05	
0.40						MADE GROUND comprising brownish red sandy gravel (hardcore)	0.20	
0.50						(Firm) light brown high strength sandy CLAY with much fine to coarse subangular to subrounded gravel	(1.10)	
1.00	ES2	ES PID	0.0ppm				1.30	
1.00								
1.30		PID	0.0ppm			(Firm) grey slightly sandy CLAY with some to much fine to coarse subangular to subrounded gravel and many cobbles of mudstone, slate and limestone	(1.30)	
1.90	ES3	ES					2.60	
						Trial pit terminated at 2.60m		

Plan (Not to Scale) 			General Remarks					
			1. Trial pit remained stable throughout excavation 2. Trial pit backfilled with arisings					
			All dimensions in metres		Scale: 1:25			
Method Used: Machine dug		Plant Used: JCB-3CX		Logged By: KHall		Checked By:		

Contract: Low Moor, Clitheroe			Client: Bowsall Ltd		Trialpit: TP10
Contract Ref: 320469	Date: 31.01.11	Ground Level (): ---	Co-ordinates: ---	Sheet: 1 of 1	

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						Grass covered TOPSOIL	(0.40)	
						(soft) brown/orange very sandy CLAY with a little fine subangular gravel	0.40	
						(soft) brown amorphous PEAT	(0.60)	
						(soft) grey very sandy CLAY with some sine to coarse subangular gravel	1.00	
							1.10	
							(0.70)	
							1.80	

Plan (Not to Scale)			General Remarks		
			1. Trial pit remained stable throughout excavation 2. Trial pit was backfilled with arisings upon completion 3. Material excavated from ground level to 0.5m bgl was noted to be waterlogged		
All dimensions in metres			Scale: 1:25		
Method Used: Machine dug	Plant Used: JCB-3CX	Logged By: KHall	Checked By:		

APPENDIX D

Ground Gas Monitoring Data

Site: Low Moor, Clitheroe
 Job No.: 320469
 Date: 10/02/2011

Borehole	Time Seconds (Minutes)	Gas Flow (l/hr)	Borehole Pressure (mB)	Methane (%v/v)	Methane (% LEL *)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Other Gases (ppm)			Depth to Water (m bgl)
								PID	H ₂ S	CO	
BH1	0	0	2.97	0		0.8	20.2		0	0	1.406 TOC
	15	0		0		0.8	19.7		0	0	1.534 GL
	30	0		0		0.8	19.5		0	0	
	45	0		0		0.8	19.5		0	0	Depth to Base
	60 (1)	0		0		0.8	19.5		0	0	9.021
	120 (2)			0		0.9	19.5		0	0	
	180 (3)			0		0.9	19.5		0	0	
	240 (4)			0		0.8	19.5		0	0	
	300 (5)										
	360 (6)										
	420 (7)										
	480 (8)										
	540 (9)										
	600 (10)										

Notes:

Monitoring order is from **left to right** across table.

Monitoring should be for **not less** than 3 minutes. However, if high concentrations of gases initially recorded, monitoring should be for up to 10 minutes

* LEL = Lower Explosive Limit = 5%v/v

Relevant Information At Time Of Monitoring				
Monitored by (name, position):		Matthew Brennen		
Atmospheric Pressure (mB):		1007		
Weather:		Sunny, damp. (Heavy rain night before, water on ground)		
Temperature (°C, between -10°C to +40°C only):				
Equipment Used (RSK Reference No.):	Infra Red Gas Analyser	Mcr Office	Last calibrated:	Feb-11
			Last calibrated:	
			Last calibrated:	
Visible Signs of Vegetation Stress:				
Other Comments / Observations:		Heavy rain night before, water on ground		
Boreholes Sampled For Laboratory Analysis:		-		

Site: Low Moor, Clitheroe
Job No.: 320469
Date: 10/02/2011



Borehole	Time Seconds (Minutes)	Gas Flow (l/hr)	Borehole Pressure (Pa)	Methane (%v/v)	Methane (% LEL *)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Other Gases (ppm)			Depth to Water (m bgl)
								PID	H ₂ S	CO	
BH2	0	-6.2		0		0	19.6		0	3	0.143
	15	-4.0		0		0	19.5		0	3	TOC
	30	-3.6		0		0	19.4		0		0.346 GL
	45	-2.7									Depth to
	60 (1)	-2.4									Base
	120 (2)										8.572
	180 (3)										
	240 (4)										
	300 (5)										
	360 (6)										
	420 (7)										
	480 (8)										
	540 (9)										
	600 (10)										

Notes:

Monitoring order is from **left to right** across table.

Monitoring should be for **not less** than 3 minutes. However, if high concentrations of gases initially recorded, monitoring should be for up to 10 minutes

* LEL = Lower Explosive Limit = 5%v/v

Relevant Information At Time Of Monitoring			
Monitored by (name, position):		Matthew Brennen	
Atmospheric Pressure (mB):		1008	
Weather:		Sunny, damp. (Heavy rain night before, water on ground)	
Temperature (°C, between -10°C to +40°C only):			
Equipment Used (RSK Reference No.):	Infra Red Gas Analyser	Mcr Office	Last calibrated: Feb-11
			Last calibrated:
			Last calibrated:
Visible Signs of Vegetation Stress:			
Other Comments / Observations:		Monitoring stopped due to water entering flow pod	
Boreholes Sampled For Laboratory Analysis:		-	

Site: Low Moor, Clitheroe
 Job No.: 320469
 Date: 18/02/2011

Borehole	Time Seconds (Minutes)	Gas Flow (l/hr)	Borehole Pressure (mB)	Methane (%v/v)	Methane (% LEL *)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Other Gases (ppm)			Depth to Water (m bgl)
								PID	H ₂ S	CO	
BH1	5	0		<0.1		<0.1	20.6		<1	<1	1.462
	15	0		<0.1		0.9	20.3		<1	<1	
	30			<0.1		0.9	19.9		<1	<1	
	45			<0.1		0.9	19.8		<1	<1	Depth to Base 9.010
	60 (1)			<0.1		1.0	19.8		<1	<1	
	90			<0.1		1.0	19.7		<1	<1	
	120 (2)			<0.1		1.0	19.7		<1	<1	
	180 (3)			<0.1		1.0	19.7		<1	<1	
	240 (4)										
	300 (5)										
	360 (6)										
	420 (7)										
	480 (8)										
	540 (9)										
	600(10)										

Notes:

Monitoring order is from **left to right** across table.

Monitoring should be for **not less** than 3 minutes. However, if high concentrations of gases initially recorded, monitoring should be for up to 10 minutes

* LEL = Lower Explosive Limit = 5%v/v

Relevant Information At Time Of Monitoring			
Monitored by (name, position):		Karl Hall	
Atmospheric Pressure (mB):		1010	
Weather:		Cool and overcast	
Temperature (°C, between -10°C to +40°C only):			
Equipment Used (RSK Reference No.):		Infra Red Gas Analyser	Mcr Office
			Last calibrated: Feb-11
			Last calibrated:
Visible Signs of Vegetation Stress:			
Other Comments / Observations:		Ground surface is sodden	
Boreholes Sampled For Laboratory Analysis:		-	

Site: Low Moor, Clitheroe
Job No.: 320469
Date: 18/02/2011



Borehole	Time Seconds (Minutes)	Gas Flow (l/hr)	Borehole Pressure (mB)	Methane (%v/v)	Methane (% LEL *)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Other Gases (ppm)			Depth to Water (m bgl)
								PID	H ₂ S	CO	
BH2	5	-7.2		<0.1		0.1	20.7		<1	<1	0.550
	15			<0.1		<0.1	20.7		<1	<1	
	30			<0.1		<0.1	20.7		<1	<1	
	45	-3.6		<0.1		<0.1	20.7		<1	<1	Depth to
	60 (1)	-2.6		<0.1		<0.1	20.7		<1	<1	Base
	90	-1.9		<0.1		<0.1	20.7		<1	<1	8.572
	120 (2)			<0.1		<0.1	20.6		<1	<1	
	180 (3)			<0.1		<0.1	20.7		<1	<1	
	240 (4)										
	300 (5)										
	360 (6)										
	420 (7)										
	480 (8)										
	540 (9)										
	600(10)										

Notes:

Monitoring order is from **left to right** across table.

Monitoring should be for **not less** than 3 minutes. However, if high concentrations of gases initially recorded, monitoring should be for up to 10 minutes

* LEL = Lower Explosive Limit = 5%v/v

Relevant Information At Time Of Monitoring				
Monitored by (name, position):		Karl Hall		
Atmospheric Pressure (mB):		1010		
Weather:		Cool and overcast		
Temperature (°C, between -10°C to +40°C only):				
Equipment Used (RSK Reference No.):		Infra Red Gas Analyser	Mcr Office	Last calibrated: Feb-11
				Last calibrated:
				Last calibrated:
Visible Signs of Vegetation Stress:				
Other Comments / Observations:		Ground surface is sodden		
Boreholes Sampled For Laboratory Analysis:		-		

Site: Low Moor, Clitheroe

Job No.: 320469

Date: 18/02/2011



Borehole	Time Seconds (Minutes)	Gas Flow (l/hr)	Borehole Pressure (mB)	Methane (%v/v)	Methane (% LEL *)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Other Gases (ppm)			Depth to Water (m bgl)
								PID	H ₂ S	CO	
BH3	5	0.3		0.3		<0.1	20.8		<1	<1	0.925
	15	0		0.3		2.1	8.9		<1	<1	
	30			0.3		2.1	8.1		<1	<1	
	45			0.3		2.1	6.8		<1	<1	
	60 (1)			0.3		2.1	6.5		<1	<1	Depth to Base 5.556
	90			0.3		2.0	6.7		<1	<1	
	120 (2)			0.3		2.0	6.8		<1	<1	
	180 (3)			0.3		2.0	7.2		<1	<1	
	240 (4)			0.3		1.9	7.8		<1	<1	
	300 (5)			0.3		1.9	7.9		<1	<1	
	360 (6)			0.4		2.0	7.6		<1	<1	
	420 (7)			0.7		2.0	7.7		<1	<1	
	480 (8)			0.8		2.0	7.7		<1	<1	
	540 (9)			0.9		2.0	7.9		<1	<1	
	600(10)			1.0		2.0	7.9		<1	<1	

Notes:

Monitoring order is from **left to right** across table.

Monitoring should be for **not less** than 3 minutes. However, if high concentrations of gases initially recorded, monitoring should be for up to 10 minutes

* LEL = Lower Explosive Limit = 5%v/v

Relevant Information At Time Of Monitoring			
Monitored by (name, position):		Karl Hall	
Atmospheric Pressure (mB):		1010	
Weather:		Cool and overcast	
Temperature (°C, between -10°C to +40°C only):			
Equipment Used (RSK Reference No.):		Infra Red Gas Analyser	Mcr Office
			Last calibrated:
			Feb-11
Visible Signs of Vegetation Stress:			
Other Comments / Observations:		Ground surface is sodden	
Boreholes Sampled For Laboratory Analysis:		-	

Site:

Job No.:

Site: Low Moor, Clitheroe
 Job No.: 320469
 Date: 02/03/2011

Borehole	Time Seconds (Minutes)	Gas Flow (l/hr)	Borehole Pressure (mB)	Methane (%v/v)	Methane (% LEL *)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Other Gases (ppm)			Depth to Water (m bgl)
								PID	H ₂ S	CO	
BH1	5	0	0.68						0	0	1.472 TOC
	10	0		0		0.7	20.8		0	0	1.598 GL
	15	0		0		0.8	20.4		0	0	
	30	0		0		0.8	20.2		0	0	Depth to Base
	60 (1)	0		0		0.8	20.2		0	0	
	90	0		0		0.8	20.2		0	0	9.021
	120 (2)	0		0		0.8	20.2		0	0	
	180 (3)	0		0		0.9	20.2		0	0	
	240 (4)			0		0.9	20.1		0	0	
	300 (5)										
	360 (6)										
	420 (7)										
	480 (8)										
	540 (9)										

Notes:

Monitoring order is from **left to right** across table.

Monitoring should be for **not less** than 3 minutes. However, if high concentrations of gases initially recorded, monitoring should be for up to 10 minutes

* LEL = Lower Explosive Limit = 5%v/v

Relevant Information At Time Of Monitoring			
Monitored by (name, position):		Matthew Brennen	
Atmospheric Pressure (mB):		1038	
Weather:		Cloudy, cool, slight breeze, dry	
Temperature (°C, between -10°C to +40°C only):			
Equipment Used (RSK Reference No.):	Infra Red Gas Analyser	Mcr office	Last calibrated: Feb-11
			Last calibrated:
			Last calibrated:
Visible Signs of Vegetation Stress:			
Other Comments / Observations:			
Boreholes Sampled For Laboratory Analysis:		-	

Site: Low Moor, Clitheroe
Job No.: 320469
Date: 02/03/2011



Borehole	Time Seconds (Minutes)	Gas Flow (l/hr)	Borehole Pressure (mB)	Methane (%v/v)	Methane (% LEL *)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Other Gases (ppm)			Depth to Water (m bgl)
								PID	H ₂ S	CO	
BH2	5	0	2.27	0		0	20.7		0	0	0.515
	10	0		0		0	20.7		0	0	TOC
	15	0		0		0	20.7		0	0	0.752 GL
	30	0		0		0	20.7		0	0	Depth to
	60 (1)	0		0		0	20.7		0	0	Base
	90	0		0		0	20.8		0	0	8.572
	120 (2)	0		0		0	20.8		0	0	
	180 (3)			0		0	20.8		0	0	
	240 (4)										
	300 (5)										
	360 (6)										
	420 (7)										
	480 (8)										
	540 (9)										

Notes:

Monitoring order is from **left to right** across table.

Monitoring should be for **not less** than 3 minutes. However, if high concentrations of gases initially recorded, monitoring should be for up to 10 minutes

* LEL = Lower Explosive Limit = 5%v/v

Relevant Information At Time Of Monitoring				
Monitored by (name, position):		Matthew Brennen		
Atmospheric Pressure (mB):		1038		
Weather:		Cloudy, cool, slight breeze, dry		
Temperature (°C, between -10°C to +40°C only):				
Equipment Used (RSK Reference No.):		Infra Red Gas Analyser	Mcr Office	Last calibrated: Feb-11
				Last calibrated:
				Last calibrated:
Visible Signs of Vegetation Stress:				
Other Comments / Observations:				
Boreholes Sampled For Laboratory Analysis:		-		

Site: Low Moor, Clitheroe

Job No.: 320469

Date: 02/03/2011



Borehole	Time Seconds (Minutes)	Gas Flow (l/hr)	Borehole Pressure (mB)	Methane (%v/v)	Methane (% LEL *)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Other Gases (ppm)			Depth to Water (m bgl)
								PID	H ₂ S	CO	
BH3	5	2.0	2.96	0					1	0	1.064
	10	1.5		2.3		2.1	12.7		1	0	TOC
	15	1.0		2.4		2.1	5.3		1	0	1.100 GL
	30	0.2		2.4		2.2	2.3		1	0	Depth to Base
	60 (1)	0		2.4		2.2	1.2		1	0	
	90			2.4		2.2	0.7		2	0	5.556
	120 (2)			2.4		2.2	0.5		1	0	
	180 (3)			2.4		2.2	0.3		2	0	
	240 (4)			2.4		2.2	0.3		1	0	
	300 (5)			2.4		2.2	0.3		2	0	
	360 (6)										
	420 (7)										
	480 (8)										
	540 (9)										

Notes:

Monitoring order is from **left to right** across table.

Monitoring should be for **not less** than 3 minutes. However, if high concentrations of gases initially recorded, monitoring should be for up to 10 minutes

* LEL = Lower Explosive Limit = 5%v/v

Relevant Information At Time Of Monitoring				
Monitored by (name, position):		Matthew Brennen		
Atmospheric Pressure (mB):		1038		
Weather:		Cloudy, cool, slight breeze, dry		
Temperature (°C, between -10°C to +40°C only):				
Equipment Used (RSK Reference No.):		Infra Red Gas Analyser	Mcr Office	Last calibrated: Feb-11
				Last calibrated:
				Last calibrated:
Visible Signs of Vegetation Stress:				
Other Comments / Observations:				
Boreholes Sampled For Laboratory Analysis:		-		

Site:

Job No.:

Site: Low Moor, Clitheroe
 Job No.: 320469
 Date: 17/03/2011

Borehole	Time Seconds (Minutes)	Gas Flow (l/hr)	Borehole Pressure (mB)	Methane (%v/v)	Methane (% LEL *)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Other Gases (ppm)			Depth to Water (m bgl)
								PID	H ₂ S	CO	
BH1	0	0									1.488
	15	0		<0.1		<0.1	21.2		<1	<1	
	30	0		<0.1		<0.1	21.3		<1	<1	
	45	0		<0.1		<0.1	21.3		<1	<1	
	60 (1)			<0.1		<0.1	21.3		<1	<1	Depth to Base
	90			<0.1		<0.1	21.3		<1	<1	9.021
	120 (2)			<0.1		<0.1	21.3		<1	<1	
	180 (3)			<0.1		<0.1	21.3		<1	<1	
	240 (4)										
	300 (5)										
	360 (6)										
	420 (7)										
	480 (8)										
	540 (9)										
	600(10)										

Notes:

Monitoring order is from **left to right** across table.

Monitoring should be for **not less** than 3 minutes. However, if high concentrations of gases initially recorded, monitoring should be for up to 10 minutes

* LEL = Lower Explosive Limit = 5%v/v

Relevant Information At Time Of Monitoring			
Monitored by (name, position):		Karl Hall	
Atmospheric Pressure (mB):		1011	
Weather:		Temperate and calm	
Temperature (°C, between -10°C to +40°C only):			
Equipment Used (RSK Reference No.):	Infra Red Gas Analyser	Mcr Office	Last calibrated: Feb-11
			Last calibrated:
			Last calibrated:
Visible Signs of Vegetation Stress:			
Other Comments / Observations:			
Boreholes Sampled For Laboratory Analysis:		-	

Site: Low Moor, Clitheroe
Job No.: 320469
Date: 17/03/2011



Borehole	Time Seconds (Minutes)	Gas Flow (l/hr)	Borehole Pressure (mB)	Methane (%v/v)	Methane (% LEL *)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Other Gases (ppm)			Depth to Water (m bgl)
								PID	H ₂ S	CO	
BH2	0	0									0.572
	15	0		<0.1		<0.1	21.6		<1	<1	
	30	0		<0.1		<0.1	21.7		<1	<1	
	45	0		<0.1		<0.1	21.7		<1	<1	
	60 (1)			<0.1		<0.1	21.7		<1	<1	Depth to Base
	90			<0.1		<0.1	21.7		<1	<1	8.572
	120 (2)			<0.1		<0.1	21.7		<1	<1	
	180 (3)			<0.1		<0.1	21.7		<1	<1	
	240 (4)										
	300 (5)										
	360 (6)										
	420 (7)										
	480 (8)										
	540 (9)										
	600(10)										

Notes:

Monitoring order is from **left to right** across table.

Monitoring should be for **not less** than 3 minutes. However, if high concentrations of gases initially recorded, monitoring should be for up to 10 minutes

* LEL = Lower Explosive Limit = 5%v/v

Relevant Information At Time Of Monitoring				
Monitored by (name, position):		Karl Hall		
Atmospheric Pressure (mB):		1011		
Weather:		Temperate and calm		
Temperature (°C, between -10°C to +40°C only):				
Equipment Used (RSK Reference No.):		Infra Red Gas Analyser	Mcr Office	Last calibrated: Feb-11
				Last calibrated:
				Last calibrated:
Visible Signs of Vegetation Stress:				
Other Comments / Observations:				
Boreholes Sampled For Laboratory Analysis:		-		

Site: Low Moor, Clitheroe

Job No.: 320469

Date: 17/03/2011



Borehole	Time Seconds (Minutes)	Gas Flow (l/hr)	Borehole Pressure (mB)	Methane (%v/v)	Methane (% LEL *)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Other Gases (ppm)			Depth to Water (m bgl)
								PID	H ₂ S	CO	
BH3	0	0		0.5		<0.1	20.0		<1	<1	0.860
	15	0		6.4		2.0	7.1		<1	<1	
	30	0		6.7		2.0	2.6		<1	<1	
	45	0		6.6		2.0	2.2		<1	<1	
	60 (1)			6.6		2.0	2.1		<1	<1	Depth to Base
	90			6.6		2.0	2.3		<1	<1	5.556
	120 (2)			6.6		2.0	2.4		<1	<1	
	180 (3)			6.4		1.9	2.8		<1	<1	
	240 (4)			6.2		1.9	3.3		<1	<1	
	300 (5)			6.4		1.9	3.5		<1	<1	
	360 (6)			6.5		1.8	4.0		<1	<1	
	420 (7)			6.5		1.8	4.4		<1	<1	
	480 (8)			6.5		1.8	4.4		<1	<1	
	540 (9)			6.7		1.8	4.7		<1	<1	
	600(10)			6.7		1.8	4.9		<1	<1	

Notes:

Monitoring order is from **left to right** across table.

Monitoring should be for **not less** than 3 minutes. However, if high concentrations of gases initially recorded, monitoring should be for up to 10 minutes

* LEL = Lower Explosive Limit = 5%v/v

Relevant Information At Time Of Monitoring			
Monitored by (name, position):		Karl Hall	
Atmospheric Pressure (mB):		1011	
Weather:		Temperate and calm	
Temperature (°C, between -10°C to +40°C only):			
Equipment Used (RSK Reference No.):		Infra Red Gas Analyser	Mcr Office
			Last calibrated:
			Feb-11
Visible Signs of Vegetation Stress:			
Other Comments / Observations:			
Boreholes Sampled For Laboratory Analysis:		-	

Site:

Job No.:

APPENDIX E

Certificates of Chemical Analysis - Soil

FINAL ANALYTICAL TEST REPORT

Envirolab Job Number: 11/00529

Issue Number: 1

Date: 16 February, 2011

Client: RSK STATS Manchester
Fourways House
57 Hilton Street
Manchester
Lancashire
UK
M1 2EJ

Project Manager: Karl Hall
Project Name: Clitheroe GI
Project Ref: 320469
Order No: Not specified
Date Samples Received: 07/02/11
Date Instructions Received: 07/02/11
Date Analysis Completed: 16/02/11

Prepared by:


Melanie Marshall
Laboratory Coordinator

Approved by:


Iain Haslock
Analytical Consultant

Notes - Soil analysis

All results are reported as dry weight (<40 °C).

Stones >10mm are removed from the sample prior to analysis and results corrected where appropriate.

Notes - General

For soil samples subscript A indicates analysis performed on the sample as received, D indicates analysis performed on dried & crushed sample.

Superscript M indicates method accredited to MCERTS.

Predominant Matrix Codes - 1 = SAND, 2 = LOAM, 3 = CLAY, 4 = LOAM/SAND, 5 = SAND/CLAY, 6 = CLAY/LOAM, 7 = OTHER.

Samples with Matrix Code 7 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our MCERTS accreditation.

Secondary Matrix Codes - A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal, E = contains roots/twigs.

IS indicates Insufficient sample for analysis. NDP indicates No Determination Possible. NFI indicates No Fibres Identified

Superscript # indicates method accredited to ISO 17025.

Accreditation for TPH (C6-C40) applies to the range C6-C36 only.

Analytical results reflect the quality of the sample at the time of analysis only.

Opinions and interpretations expressed are outside the scope of our accreditation.

Envirolab Job Number: 11/00529

Client Project Name: Clitheroe GI

Client Project Ref: 320469

Lab Sample ID	11/00529/1	11/00529/5	11/00529/10	11/00529/13	11/00529/15	11/00529/20	11/00529/26	11/00529/27	Units	Method ref
Client Sample No										
Client Sample ID	BH1	BH1	BH2	BH3	BH3	TP-1	TP-2	TP-2		
Depth to Top	0.50	6.00	2.00	0.50	3.00	1.10	0.60	1.80		
Depth To Bottom	1.00			1.00						
Date Sampled	31-Jan-11	31-Jan-11	31-Jan-11	01-Feb-11	01-Feb-11	31-Jan-11	31-Jan-11	31-Jan-11		
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil		
Sample Matrix Code	5A	3	5A	6AE	5A	6DE	6ADE	5		
ACM Screen _A	-	-	-	NFI	-	-	NFI	-		Visual
pH _D ^{M#}	8.1	8.3	8.5	8.3	8.5	-	8.5	-	pH	A-T-031s
Sulphate BRE (water sol 2:1) _D ^{M#}	-	0.11	0.09	0.06	0.03	-	-	-	g/l	A-T-026s
Total Organic Carbon _D [#]	2.33	-	-	1.67	-	-	8.08	1.36	% w/w	A-T-032s
Arsenic _D ^{M#}	11	-	-	8	-	-	13	-	mg/kg	A-T-024
Cadmium _D ^{M#}	1.0	-	-	<0.5	-	-	0.9	-	mg/kg	A-T-024
Copper _D ^{M#}	21	-	-	30	-	-	50	-	mg/kg	A-T-024
Chromium _D ^{M#}	23	-	-	27	-	-	24	-	mg/kg	A-T-024
Lead _D ^{M#}	35	-	-	37	-	-	269	-	mg/kg	A-T-024
Mercury _D	<0.17	-	-	<0.17	-	-	1.19	-	mg/kg	A-T-024
Nickel _D ^{M#}	22	-	-	20	-	-	28	-	mg/kg	A-T-024
Selenium _D ^{M#}	2	-	-	2	-	-	2	-	mg/kg	A-T-024
Zinc _D ^{M#}	93	-	-	67	-	-	187	-	mg/kg	A-T-024

Envirolab Job Number: 11/00529

Client Project Name: Clitheroe GI

Client Project Ref: 320469

Lab Sample ID	11/00529/1	11/00529/5	11/00529/10	11/00529/13	11/00529/15	11/00529/20	11/00529/26	11/00529/27	Units	Method ref
Client Sample No										
Client Sample ID	BH1	BH1	BH2	BH3	BH3	TP-1	TP-2	TP-2		
Depth to Top	0.50	6.00	2.00	0.50	3.00	1.10	0.60	1.80		
Depth To Bottom	1.00			1.00						
Date Sampled	31-Jan-11	31-Jan-11	31-Jan-11	01-Feb-11	01-Feb-11	31-Jan-11	31-Jan-11	31-Jan-11		
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil		
Sample Matrix Code	5A	3	5A	6AE	5A	6DE	6ADE	5		
TPH CWG										
Ali >C5-C6 _A	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s
Ali >C6-C8 _A	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s
Ali >C8-C10 _A	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s
Ali >C10-C12 _A [#]	<0.1	-	-	<0.1	-	<0.1	<0.1	<0.1	mg/kg	A-T-023s
Ali >C12-C16 _A [#]	<0.1	-	-	<0.1	-	<0.1	<0.1	1.2	mg/kg	A-T-023s
Ali >C16-C21 _A [#]	<0.1	-	-	<0.1	-	11.0	5.9	<0.1	mg/kg	A-T-023s
Ali >C21-C35 _A [#]	<0.1	-	-	<0.1	-	45.4	97.5	1.2	mg/kg	A-T-023s
Total Aliphatics _A [#]	<0.1	-	-	<0.1	-	56.4	103	2.4	mg/kg	A-T-022+23s
Aro >C5-C7 _A	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s
Aro >C7-C8 _A	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s
Aro >C8-C9 _A	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s
Aro >C9-C10 _A	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s
Aro >C10-C12 _A [#]	<0.1	-	-	<0.1	-	<0.1	<0.1	<0.1	mg/kg	A-T-023s
Aro >C12-C16 _A [#]	<0.1	-	-	<0.1	-	<0.1	<0.1	<0.1	mg/kg	A-T-023s
Aro >C16-C21 _A [#]	<0.1	-	-	<0.1	-	<0.1	<0.1	<0.1	mg/kg	A-T-023s
Aro >C21-C35 _A [#]	<0.1	-	-	<0.1	-	<0.1	<0.1	<0.1	mg/kg	A-T-023s
Total Aromatics _A [#]	<0.1	-	-	<0.1	-	<0.1	<0.1	<0.1	mg/kg	A-T-022+23s
TPH (Ali & Aro) _A [#]	<0.1	-	-	<0.1	-	56.4	103	2.4	mg/kg	A-T-022+23s
BTEX - Benzene _A [#]	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s
BTEX - Toluene _A [#]	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s
BTEX - Ethyl Benzene _A [#]	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s
BTEX - m & p Xylene _A [#]	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s
BTEX - o Xylene _A [#]	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s
MTBE _A [#]	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	mg/kg	A-T-022s

Envirolab Job Number: 11/00529

Client Project Name: Clitheroe GI

Client Project Ref: 320469

Lab Sample ID	11/00529/1	11/00529/5	11/00529/10	11/00529/13	11/00529/15	11/00529/20	11/00529/26	11/00529/27	Units	Method ref
Client Sample No										
Client Sample ID	BH1	BH1	BH2	BH3	BH3	TP-1	TP-2	TP-2		
Depth to Top	0.50	6.00	2.00	0.50	3.00	1.10	0.60	1.80		
Depth To Bottom	1.00			1.00						
Date Sampled	31-Jan-11	31-Jan-11	31-Jan-11	01-Feb-11	01-Feb-11	31-Jan-11	31-Jan-11	31-Jan-11		
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil		
Sample Matrix Code	5A	3	5A	6AE	5A	6DE	6ADE	5		
PAH 16										
Acenaphthene _A ^{M#}	-	-	-	0.03	-	-	0.06	-	mg/kg	A-T-019s
Acenaphthylene _A ^{M#}	-	-	-	<0.01	-	-	0.04	-	mg/kg	A-T-019s
Anthracene _A ^{M#}	-	-	-	0.03	-	-	0.12	-	mg/kg	A-T-019s
Benzo(a)anthracene _A [#]	-	-	-	0.08	-	-	0.94	-	mg/kg	A-T-019s
Benzo(a)pyrene _A ^{M#}	-	-	-	0.08	-	-	0.92	-	mg/kg	A-T-019s
Benzo(b)fluoranthene _A ^{M#}	-	-	-	0.06	-	-	0.81	-	mg/kg	A-T-019s
Benzo(ghi)perylene _A ^{M#}	-	-	-	0.12	-	-	1.05	-	mg/kg	A-T-019s
Benzo(k)fluoranthene _A	-	-	-	0.02	-	-	0.37	-	mg/kg	A-T-019s
Chrysene _A ^{M#}	-	-	-	0.16	-	-	1.29	-	mg/kg	A-T-019s
Dibenzo(ah)anthracene _A [#]	-	-	-	0.02	-	-	0.16	-	mg/kg	A-T-019s
Fluoranthene _A ^{M#}	-	-	-	0.17	-	-	1.16	-	mg/kg	A-T-019s
Fluorene _A ^{M#}	-	-	-	<0.01	-	-	0.01	-	mg/kg	A-T-019s
Indeno(123-cd)pyrene _A [#]	-	-	-	0.03	-	-	0.73	-	mg/kg	A-T-019s
Napthalene _A ^{M#}	-	-	-	<0.01	-	-	0.07	-	mg/kg	A-T-019s
Phenanthrene _A ^{M#}	-	-	-	0.03	-	-	0.34	-	mg/kg	A-T-019s
Pyrene _A ^{M#}	-	-	-	0.19	-	-	1.25	-	mg/kg	A-T-019s
Total PAH _A [#]	-	-	-	1.03	-	-	9.31	-	mg/kg	A-T-019s

Envirolab Job Number: 11/00529

Client Project Name: Clitheroe GI

Client Project Ref: 320469

Lab Sample ID	11/00529/31	11/00529/37	11/00529/42	11/00529/44	11/00529/46				Units	Method ref
Client Sample No										
Client Sample ID	TP-3	TP-5	TP-7	TP-8	TP-9					
Depth to Top	1.50	0.30	2.50	0.10	0.40					
Depth To Bottom										
Date Sampled	31-Jan-11	31-Jan-11	31-Jan-11	31-Jan-11	31-Jan-11					
Sample Type	Soil	Soil	Soil	Soil	Soil					
Sample Matrix Code	5	5AE	3	4E	5A					
pH _D ^{M#}	7.9	7.7	8.6	7.2	7.4				pH	A-T-031s
Sulphate BRE (water sol 2:1) _D ^{M#}	-	<0.01	0.01	-	-				g/l	A-T-026s
Total Organic Carbon _D [#]	4.32	1.94	-	4.95	0.76				% w/w	A-T-032s
Arsenic _D ^{M#}	6	8	-	16	9				mg/kg	A-T-024
Cadmium _D ^{M#}	0.6	<0.5	-	0.8	1.1				mg/kg	A-T-024
Copper _D ^{M#}	34	14	-	73	30				mg/kg	A-T-024
Chromium _D ^{M#}	22	18	-	34	40				mg/kg	A-T-024
Chromium (hexavalent) Dep _D	-	-	-	-	<1				mg/kg	A-T-040s
Lead _D ^{M#}	41	26	-	130	36				mg/kg	A-T-024
Mercury _D	<0.17	<0.17	-	<0.17	<0.17				mg/kg	A-T-024
Nickel _D ^{M#}	20	14	-	31	49				mg/kg	A-T-024
Selenium _D ^{M#}	<1	<1	-	2	3				mg/kg	A-T-024
Zinc _D ^{M#}	110	60	-	151	141				mg/kg	A-T-024

Envirolab Job Number: 11/00529

Client Project Name: Clitheroe GI

Client Project Ref: 320469

Lab Sample ID	11/00529/31	11/00529/37	11/00529/42	11/00529/44	11/00529/46				Units	Method ref
Client Sample No										
Client Sample ID	TP-3	TP-5	TP-7	TP-8	TP-9					
Depth to Top	1.50	0.30	2.50	0.10	0.40					
Depth To Bottom										
Date Sampled	31-Jan-11	31-Jan-11	31-Jan-11	31-Jan-11	31-Jan-11					
Sample Type	Soil	Soil	Soil	Soil	Soil					
Sample Matrix Code	5	5AE	3	4E	5A					
TPH CWG										
Ali >C5-C6 _A	<0.01	-	-	-	-				mg/kg	A-T-022s
Ali >C6-C8 _A	<0.01	-	-	-	-				mg/kg	A-T-022s
Ali >C8-C10 _A	<0.01	-	-	-	-				mg/kg	A-T-022s
Ali >C10-C12 _A [#]	<0.1	-	-	-	-				mg/kg	A-T-023s
Ali >C12-C16 _A [#]	1.7	-	-	-	-				mg/kg	A-T-023s
Ali >C16-C21 _A [#]	<0.1	-	-	-	-				mg/kg	A-T-023s
Ali >C21-C35 _A [#]	4.9	-	-	-	-				mg/kg	A-T-023s
Total Aliphatics _A [#]	6.4	-	-	-	-				mg/kg	A-T-022+23s
Aro >C5-C7 _A	<0.01	-	-	-	-				mg/kg	A-T-022s
Aro >C7-C8 _A	<0.01	-	-	-	-				mg/kg	A-T-022s
Aro >C8-C9 _A	<0.01	-	-	-	-				mg/kg	A-T-022s
Aro >C9-C10 _A	<0.01	-	-	-	-				mg/kg	A-T-022s
Aro >C10-C12 _A [#]	<0.1	-	-	-	-				mg/kg	A-T-023s
Aro >C12-C16 _A [#]	<0.1	-	-	-	-				mg/kg	A-T-023s
Aro >C16-C21 _A [#]	<0.1	-	-	-	-				mg/kg	A-T-023s
Aro >C21-C35 _A [#]	<0.1	-	-	-	-				mg/kg	A-T-023s
Total Aromatics _A [#]	<0.1	-	-	-	-				mg/kg	A-T-022+23s
TPH (Ali & Aro) _A [#]	6.4	-	-	-	-				mg/kg	A-T-022+23s
BTEX - Benzene _A [#]	<0.01	-	-	-	-				mg/kg	A-T-022s
BTEX - Toluene _A [#]	<0.01	-	-	-	-				mg/kg	A-T-022s
BTEX - Ethyl Benzene _A [#]	<0.01	-	-	-	-				mg/kg	A-T-022s
BTEX - m & p Xylene _A [#]	<0.01	-	-	-	-				mg/kg	A-T-022s
BTEX - o Xylene _A [#]	<0.01	-	-	-	-				mg/kg	A-T-022s
MTBE _A [#]	<0.01	-	-	-	-				mg/kg	A-T-022s

Envirolab Job Number: 11/00529

Client Project Name: Clitheroe GI

Client Project Ref: 320469

Lab Sample ID	11/00529/31	11/00529/37	11/00529/42	11/00529/44	11/00529/46				Units	Method ref
Client Sample No										
Client Sample ID	TP-3	TP-5	TP-7	TP-8	TP-9					
Depth to Top	1.50	0.30	2.50	0.10	0.40					
Depth To Bottom										
Date Sampled	31-Jan-11	31-Jan-11	31-Jan-11	31-Jan-11	31-Jan-11					
Sample Type	Soil	Soil	Soil	Soil	Soil					
Sample Matrix Code	5	5AE	3	4E	5A					
PAH 16										
Acenaphthene _A ^{M#}	0.02	0.01	-	-	0.04				mg/kg	A-T-019s
Acenaphthylene _A ^{M#}	<0.01	<0.01	-	-	<0.01				mg/kg	A-T-019s
Anthracene _A ^{M#}	0.04	0.02	-	-	0.02				mg/kg	A-T-019s
Benzo(a)anthracene _A [#]	0.06	0.04	-	-	0.05				mg/kg	A-T-019s
Benzo(a)pyrene _A ^{M#}	0.08	0.01	-	-	0.05				mg/kg	A-T-019s
Benzo(b)fluoranthene _A ^{M#}	0.07	0.02	-	-	<0.01				mg/kg	A-T-019s
Benzo(ghi)perylene _A ^{M#}	0.11	0.02	-	-	0.04				mg/kg	A-T-019s
Benzo(k)fluoranthene _A	0.04	<0.01	-	-	<0.01				mg/kg	A-T-019s
Chrysene _A ^{M#}	0.14	0.07	-	-	0.09				mg/kg	A-T-019s
Dibenzo(ah)anthracene _A [#]	<0.01	<0.01	-	-	<0.01				mg/kg	A-T-019s
Fluoranthene _A ^{M#}	0.15	0.06	-	-	0.07				mg/kg	A-T-019s
Fluorene _A ^{M#}	<0.01	<0.01	-	-	<0.01				mg/kg	A-T-019s
Indeno(123-cd)pyrene _A [#]	0.02	<0.01	-	-	<0.01				mg/kg	A-T-019s
Napthalene _A ^{M#}	<0.01	0.01	-	-	<0.01				mg/kg	A-T-019s
Phenanthrene _A ^{M#}	0.08	0.06	-	-	0.09				mg/kg	A-T-019s
Pyrene _A ^{M#}	0.14	0.06	-	-	0.09				mg/kg	A-T-019s
Total PAH _A [#]	0.97	0.40	-	-	0.54				mg/kg	A-T-019s

APPENDIX F

Certificates of Chemical Analysis – Groundwater

FINAL ANALYTICAL TEST REPORT

Envirolab Job Number: 11/00601

Issue Number: 1

Date: 24 February, 2011

Client: RSK STATS Manchester
Fourways House
57 Hilton Street
Manchester
Lancashire
UK
M1 2EJ

Project Manager: Karl Hall/Matthew Brennen
Project Name: Low Moor, Clitheroe
Project Ref: 320469
Order No: Not specified
Date Samples Received: 11/02/11
Date Instructions Received: 11/02/11
Date Analysis Completed: 18/02/11

Prepared by:



Melanie Marshall
Laboratory Coordinator

Approved by:



John Gustafson
Director

Notes - General

For soil samples subscript A indicates analysis performed on the sample as received, D indicates analysis performed on dried & crushed sample.

Superscript M indicates method accredited to MCERTS.

Predominant Matrix Codes - 1 = SAND, 2 = LOAM, 3 = CLAY, 4 = LOAM/SAND, 5 = SAND/CLAY, 6 = CLAY/LOAM, 7 = OTHER. Samples with Matrix Code 7 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our MCERTS accreditation. Secondary Matrix Codes - A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal, E = contains roots/twigs.

IS indicates Insufficient sample for analysis. NDP indicates No Determination Possible. NFI indicates No Fibres Identified.

Superscript # indicates method accredited to ISO 17025.

Accreditation for TPH (C6-C40) applies to the range C6-C36 only.

Analytical results reflect the quality of the sample at the time of analysis only.

Opinions and interpretations expressed are outside the scope of our accreditation.

Envirolab Job Number: 11/00601

Client Project Name: Low Moor, Clitheroe

Client Project Ref: 320469

Lab Sample ID	11/00601/1	11/00601/2	11/00601/3						Units	Method ref
Client Sample No										
Client Sample ID	BH1	BH2	BH3							
Depth to Top										
Depth To Bottom										
Date Sampled	10-Feb-11	10-Feb-11	10-Feb-11							
Sample Type	Water - W	Water - W	Water - W							
Sample Matrix Code										
Arsenic (dissolved) _A [#]	<1	1	2						µg/l	A-T-025
Boron (dissolved) _A [#]	30	31	27						µg/l	A-T-025
Cadmium (dissolved) _A [#]	<1	<1	<1						µg/l	A-T-025
Copper (dissolved) _A [#]	4	1	4						µg/l	A-T-025
Chromium (dissolved) _A [#]	<1	1	2						µg/l	A-T-025
Lead (dissolved) _A [#]	<1	3	<1						µg/l	A-T-025
Mercury (dissolved) _A [#]	0.3	0.3	1.0						µg/l	A-T-025
Nickel (dissolved) _A [#]	1	4	1						µg/l	A-T-025
Selenium (dissolved) _A [#]	<1	<1	<1						µg/l	A-T-025
Zinc (dissolved) _A [#]	11	59	<1						µg/l	A-T-025

Envirolab Job Number: 11/00601

Client Project Name: Low Moor, Clitheroe

Client Project Ref: 320469

Lab Sample ID	11/00601/1	11/00601/2	11/00601/3						Units	Method ref
Client Sample No										
Client Sample ID	BH1	BH2	BH3							
Depth to Top										
Depth To Bottom										
Date Sampled	10-Feb-11	10-Feb-11	10-Feb-11							
Sample Type	Water - W	Water - W	Water - W							
Sample Matrix Code										
TPH CWG										
Ali >C5-C6 (w) _A [#]	<1	<1	<1						µg/l	A-T-022w
Ali >C6-C8 (w) _A [#]	<1	<1	<1						µg/l	A-T-022w
Ali >C8-C10 (w) _A [#]	<1	<1	<1						µg/l	A-T-022w
Ali >C10-C12 (w) _A [#]	<5	<5	<5						µg/l	A-T-023w
Ali >C12-C16 (w) _A [#]	<5	<5	<5						µg/l	A-T-023w
Ali >C16-C21 (w) _A [#]	<5	<5	<5						µg/l	A-T-023w
Ali >C21-C35 (w) _A [#]	<5	<5	<5						µg/l	A-T-023w
Total Aliphatics (w) _A [#]	<5	<5	<5						µg/l	A-T-022+23w
Aro >C5-C7 (w) _A [#]	<1	<1	<1						µg/l	A-T-022w
Aro >C7-C8 (w) _A [#]	<1	<1	<1						µg/l	A-T-022w
Aro >C8-C9 (w) _A [#]	<1	<1	<1						µg/l	A-T-022w
Aro >C9-C10 (w) _A [#]	<1	<1	<1						µg/l	A-T-022w
Aro >C10-C12 (w) _A [#]	<5	<5	<5						µg/l	A-T-023w
Aro >C12-C16 (w) _A [#]	<5	<5	<5						µg/l	A-T-023w
Aro >C16-C21 (w) _A [#]	<5	<5	<5						µg/l	A-T-023w
Aro >C21-C35 (w) _A [#]	<5	<5	<5						µg/l	A-T-023w
Total Aromatics (w) _A [#]	<5	<5	<5						µg/l	A-T-022+23w
TPH (Ali & Aro) (w) _A [#]	<5	<5	<5						µg/l	A-T-022+23w
BTEX - Benzene (w) _A [#]	<1	<1	<1						µg/l	A-T-022w
BTEX - Ethyl Benzene (w) _A [#]	<1	<1	<1						µg/l	A-T-022w
BTEX - Toluene (w) _A [#]	<1	<1	<1						µg/l	A-T-022w
BTEX - m & p Xylene (w) _A [#]	<1	<1	<1						µg/l	A-T-022w
BTEX - o Xylene (w) _A [#]	<1	<1	<1						µg/l	A-T-022w
MTBE (w) _A [#]	<1	<1	<1						µg/l	A-T-022w

Envirolab Job Number: 11/00601

Client Project Name: Low Moor, Clitheroe

Client Project Ref: 320469

Lab Sample ID	11/00601/1	11/00601/2	11/00601/3						Units	Method ref
Client Sample No										
Client Sample ID	BH1	BH2	BH3							
Depth to Top										
Depth To Bottom										
Date Sampled	10-Feb-11	10-Feb-11	10-Feb-11							
Sample Type	Water - W	Water - W	Water - W							
Sample Matrix Code										
PAH-16MS (w)										
Acenaphthene (w) _A [#]	-	<0.01	0.54						µg/l	A-T-019w
Acenaphthylene (w) _A [#]	-	<0.01	0.01						µg/l	A-T-019w
Anthracene (w) _A [#]	-	<0.01	<0.01						µg/l	A-T-019w
Benzo(a)anthracene (w) _A [#]	-	<0.01	<0.01						µg/l	A-T-019w
Benzo(a)pyrene (w) _A [#]	-	<0.01	<0.01						µg/l	A-T-019w
Benzo(b)fluoranthene (w) _A [#]	-	<0.01	<0.01						µg/l	A-T-019w
Benzo(ghi)perylene (w) _A [#]	-	<0.01	<0.01						µg/l	A-T-019w
Benzo(k)fluoranthene (w) _A [#]	-	<0.01	<0.01						µg/l	A-T-019w
Chrysene (w) _A [#]	-	<0.01	<0.01						µg/l	A-T-019w
Dibenzo(ah)anthracene (w) _A [#]	-	<0.01	<0.01						µg/l	A-T-019w
Fluoranthene (w) _A [#]	-	<0.01	0.01						µg/l	A-T-019w
Fluorene (w) _A [#]	-	<0.01	0.30						µg/l	A-T-019w
Indeno(123-cd)pyrene (w) _A [#]	-	<0.01	<0.01						µg/l	A-T-019w
Naphthalene (w) _A [#]	-	<0.01	0.04						µg/l	A-T-019w
Phenanthrene (w) _A [#]	-	<0.01	0.05						µg/l	A-T-019w
Pyrene (w) _A [#]	-	0.01	0.02						µg/l	A-T-019w
Total PAH (w) _A [#]	-	0.01	0.97						µg/l	A-T-019w

APPENDIX G

Variable Head Permeability Test Spreadsheets

Project No: 320469		Variable Head Test In Borehole One (BH1)		
Date: 31-Jan-11		Type of test: Falling Head Test		
Site: Clitheroe				
Time Elapsed (mins)	Depth at time t	Ht	Ht/Ho	Log Ht/Ho
0	0.01	-0.79	1	0
1	0.09	-0.71	0.899	-0.046
2	0.11	-0.69	0.873	-0.059
3	0.12	-0.68	0.861	-0.065
4	0.14	-0.66	0.835	-0.078
5	0.17	-0.63	0.797	-0.099
10	0.19	-0.61	0.772	-0.112
15	0.25	-0.55	0.696	-0.157
20	0.80	0.00	0	#NUM!
25	0.80	0.00	0	#NUM!
30	0.80	0.00	0	#NUM!
40	0.80	0.00	0	#NUM!
60	0.80	0.00	0	#NUM!

TEST PARAMETERS

Timelag calculated using slope of plot where:

T1 = 0 mins

T2 = 15 mins

Timelag (T), where Ht/Ho=0.37: 40.81 mins

TEST CONDITIONS (at time of test)

Depth of borehole 10.00 m

Depth of casing 9.00 m

INTAKE FACTOR F

D (Diameter) 0.15 m

L* 1.00 m

L/D ratio= 6.7E+00

Notes:

L* is assumed to be the length of the filter response zone. Where the response zone is not fully saturated prior to head test, then L is Where standpipes

Well or BH response zone extended in uniform soil BS5930 case X : F=

CROSS SECTION

A assumed to

A assumed to

Diameter of s

Parameters	Calculated value	Comment on Result
Rest Water Level	0.80 m	
Ho=	-0.79 m	
Borehole Diameter (D)	0.15 m	
Shape Factor (F)	17.28	
Cross-sectional Area (A)	1.77E-02 m2	
Hydraulic Conductivity	K=A/FT	
	= 4.E-07 m/sec	

Values of intake factors F as per BS5930, dependant upon test conditions correct equation and case description to be pasted in row above overwriting default

BS5930 Figure 7 used to determine F

Soil flush with bottom at impervious boundary	BS5930 case a : F=	
Soil flush with bottom in uniform soil	BS5930 case b : F=	
Well or BH response zone extended at impervious	BS5930 case c : F=	
Well or BH response zone extended in uniform soil	BS5930 case d : F=	17.28

Project No: 320469		Variable Head Test In Borehole Three(BH3)		
Date: 01-Feb-11		Type of test: Falling Head Test		
Site: Clitheroe				
Time Elapsed (mins)	Depth at time t	Ht	Ht/Ho	Log Ht/Ho
0	0.01	-0.68	1	0
1	0.20	-0.49	0.721	-0.142
2	0.27	-0.42	0.618	-0.209
3	0.35	-0.34	0.5	-0.301
4	0.41	-0.28	0.412	-0.385
5	0.48	-0.21	0.309	-0.51
10	0.62	-0.07	0.103	-0.987
15	0.64	-0.05	0.074	-1.131
20	0.67	-0.02	0.029	-1.538
25	0.69	0.00	0	#NUM!
30	0.69	0.00	0	#NUM!
40	0.69	0.00	0	#NUM!
60	0.69	0.00	0	#NUM!

TEST PARAMETERS

Timelag calculated using slope of plot where:

T1 = 0 mins

T2 = 25 mins

Timelag (T), where Ht/Ho=0.37: 4.75 mins

TEST CONDITIONS (at time of test)

Depth of borehole	6.20 m
Depth of casing	5.00 m

INTAKE FACTOR F

D (Diameter)	0.15 m
L*	1.20 m
L/D ratio=	8.0E+00

CROSS SECTIONAL AREA

Parameters	Calculated value	Comment on Result
Rest Water Level	0.69 m	
Ho=	-0.68 m	
Borehole Diameter (D)	0.15 m	
Shape Factor (F)	2.72	
A assumed to	Cross-sectional Area (A)	1.77E-02 m2
A assumed to	Hydraulic Conductivity	K=A/FT
Diameter of s		= 2.E-05 m/sec

Notes:

L* is assumed to be the length of the filter response zone. Where the response zone is not fully saturated prior to head test, then L is considered to represent the distance between the Rest Water Level and the base of the response zone. Where strata l Where standpipes

Well or BH response zone extended in uniform soil BS5930 case X : F=

Values of intake factors F as per BS5930, dependant upon test conditions correct equation and case description to be pasted in row above overwriting default

BS5930 Figure 7 used to determine F

Soil flush with bottom at impervious boundary	BS5930 case a : F=
Soil flush with bottom in uniform soil	BS5930 case b : F=
Well or BH response zone extended at impervious	BS5930 case c : F=
Well or BH response zone extended in uniform soil	BS5930 case d : F= 2.72

APPENDIX H

Generic Assessment Criteria for Human Health

Generic Assessment Criteria for Human Health
Residential Scenario – Private Gardens

The human health generic assessment criteria (GAC) have been developed during a period of regulatory review and updating of the Contaminated Land Exposure Assessment (CLEA) project. Hence, the Environment Agency (EA) is in the process of publishing updated reports relating to the CLEA project and the GAC presented in this document may change to reflect these updates. This issue was prepared following the publication of soil guideline value reports and associated publications⁽¹⁾ for mercury, selenium, benzene, toluene, ethylbenzene and xylene in March 2009, arsenic and nickel in May 2009, cadmium and phenol in June 2009, dioxins, furans and dioxin-like PCBs in September 2009. It was also produced following publication of GAC by LQM⁽⁶⁾. Where available, the published soil guideline values (SGV)⁽¹⁾ have been used as GAC.

1. Model Selection

Soil assessment criteria (SAC) were calculated using CLEA v1.06 and the supporting UK guidance⁽¹⁻⁶⁾. Groundwater assessment criteria (GrAC) protective of human health via the inhalation pathway were derived using the RBCA 1.3b model. RSK has updated the inputs within RBCA to reflect the UK guidance⁽¹⁻⁵⁾. The SAC and GrAC collectively are termed GAC.

2. Conceptual Model

In accordance with EA Science Report SC050221/SR3⁽³⁾, the residential with private garden scenario considers risks to a female child between the ages of 0 and 6 years old. In accordance with Box 3.1, SR3⁽³⁾, the pathways considered for production of the SAC in the residential with gardens scenario are:

- Direct soil and dust ingestion;
- Consumption of homegrown produce;
- Consumption of soil attached to homegrown produce;
- Dermal contact with soil and indoor dust, and
- Inhalation of indoor and outdoor dust and vapours.

Figure 1 is a conceptual model illustrating these linkages.

The pathway considered in production of the GrAC is the volatilisation of compounds from groundwater and subsequent vapour inhalation by residents whilst indoors. Figure 2 illustrates this linkage. Although the outdoor air inhalation pathway is also valid, this contributes little to the overall risks owing to the dilution in outdoor air. Within RBCA, the solubility limit of the determinant restricts the extent of volatilisation, which in turn drives the indoor air inhalation pathway. Whilst the same restriction is not built into the CLEA model, the CLEA model output cells are flagged red where the soil saturation limit has been exceeded.

An assumption used in the CLEA model is that of simple linear partitioning of a chemical in the soil between the sorbed, dissolved and vapour phase⁽⁴⁾. The upper boundaries of this partitioning are represented by the aqueous solubility and pure saturated vapour concentration of the chemical. The CLEA software uses a traffic light system to identify when individual and/or combined assessment criteria exceed the lower of either the aqueous or vapour based saturation limits. Where model output cells are flagged red the soil or vapour saturation limit has been exceeded and further consideration of the SAC to be used within the assessment is required. One approach that could be adopted is to use the 'modelled' solubility saturation limit or vapour saturation limit of the compound as the SAC. However, as stated within the CLEA Handbook⁽⁴⁾ this is likely to not be practical in many cases because of the very low limits

and is in any case highly conservative. Unless free-phase product is present, concentrations of the chemical are unlikely to be present at sufficient concentration to result in an exceedance of the health criteria value (HCV).

RSK has adopted an approach for petroleum hydrocarbons in accordance with LQM/CIEH⁽⁶⁾ whereby the concentration modelled for each petroleum hydrocarbon fraction has been tabulated as the SAC with the corresponding solubility or vapour saturation limit given in brackets. Therefore, when using the SAC's to screen laboratory analysis the assessor should take note if a given SAC has a corresponding solubility or vapour saturation limit (in brackets), and subsequently incorporate this piece of information within the screening analytical discussion. If further assessment is required following this process then an additional approach can be utilised as detailed within Section 4.12 of the CLEA model manual⁽⁴⁾ which explains how to calculate an effective assessment criterion manually.

3. Input Selection

Chemical data was obtained from EA Report SC050021/SR7⁽⁵⁾ and the health criteria values (HCV) from the UK TOX⁽¹⁾ reports where available. For SAC for total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH) toxicological and chemical specific parameters were obtained from the LQM/CIEH report⁽⁶⁾. Similarly, toxicological and specific chemical parameters for the volatile organic compound 1,2,4-trimethylbenzene were obtained from EIC/AGS/CL:AIRE⁽⁷⁾.

For total petroleum hydrocarbons (TPH), aromatic hydrocarbons C₅-C₈ were not modelled since benzene and toluene are being modelled separately. The aromatic C₈-C₉ hydrocarbon fraction comprises ethylbenzene, xylene and styrene. Since ethylbenzene and xylene are being modelled separately, the physical, chemical and toxicological data for this band has been taken from styrene.

Owing to the lack of UK-specific data, default information in the RBCA model was used to evaluate methyl tertiary butyl ether (MTBE). No published UK data was available for 1,3,5-trimethylbenzene, so information was obtained from the US EPA as in the RBCA model. RBCA uses toxicity data for the inhalation pathway in different units to the CLEA model and cannot consider separately the mean daily intake (MDI), occupancy periods or breathing rates. Therefore, the HCV in RBCA was amended to take account of:

- Amendments to the MDI using Table 3.4 of SR2⁽²⁾;
- A child weighing 13.3kg (average of 0-6 year old female in accordance with Table 4.6 of SR3⁽³⁾) and breathing 11.85m³ (average daily inhalation rate for a 0-6 yr old female in accordance with Table 4.14 of SR3⁽³⁾); and
- The 50% rule (for petroleum hydrocarbons, 1,3,5-trimethylbenzene and MTBE)⁽²⁾ where MDI data is not available but background exposure is considered important in the overall exposure.

4. Physical Parameters

For the residential with private gardens scenario, the CLEA default building is a small two-storey terrace house with concrete ground bearing slab. The house is assumed to have a 100m² private garden consisting of lawn, flowerbeds and incorporating a 20m² plot for growing fruit and vegetables consumed by the residents. SR3⁽³⁾ notes this residential building type to be the most conservative in terms of protection from vapour intrusion. The building parameters are outlined in Table 5.

The parameters for a sandy loam soil type were used in line with SR3⁽³⁾. This includes a value of 6% for the percentage soil organic matter (SOM) within the soil. In RSK's experience, this is rather high for many sites. To avoid undertaking site specific risk assessments for this parameter, RSK has produced an

additional set of SAC for an SOM of 1% and 2.5%. For the GrAC, the depth to groundwater was taken as 2.5m based on RSK's experience of assessing the volatilisation pathway from groundwater.

5. GAC

The SAC were produced using the input parameters in Tables 1 to 5 and the GrAC using input parameters in Table 6. The final selected GAC are presented by pathway in Table 7 and the combined GAC in Table 8.

Figure 1
Conceptual Model for CLEA Residential Scenario – Private Gardens

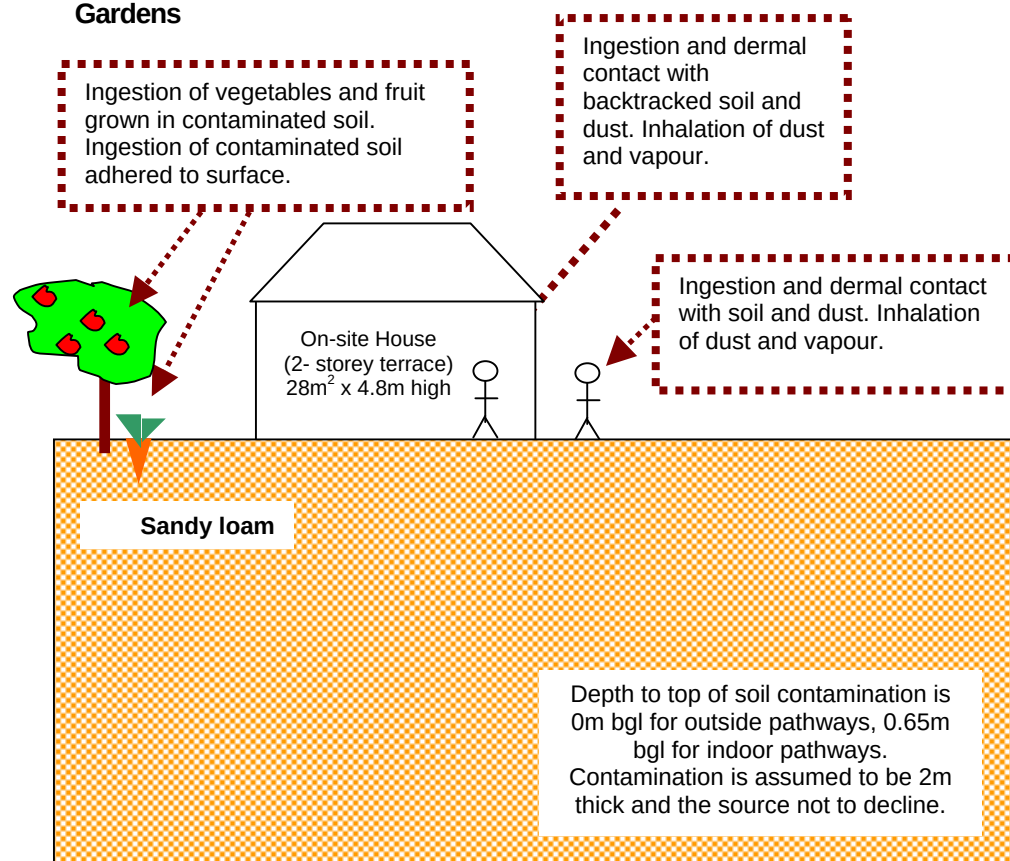


Table 1
Exposure Assessment Parameters for Residential Scenario - Private Gardens – Inputs for CLEA Model

Parameter	Value	Justification
Land use	Residential with homegrown produce	Chosen land use
Receptor	Female child age 1 to 6	Key generic assumption given in Box 3.1, report SC050021/SR3 ⁽³⁾
Building	Small terraced house	Key generic assumption given in Box 3.1, report SC050021/SR3. Two storey small terraced house chosen as it is the most conservative residential building type in terms of protection from vapor intrusion (Section 3.4.6, report SC050021/SR3) ⁽³⁾
Soil type	Sandy Loam	Most common UK soil type (Section 4.3.1, From Table 3.1, report SC050021/SR3) ⁽³⁾
Start AC (age class)	1	Range of age classes corresponding to key generic assumption that the critical receptor is a young female child aged zero to six. From Box 3.1, report SC050021/SR3 ⁽³⁾
End AC (age class)	6	
SOM (%)	6	Representative of sandy loamy soil according to EA Guidance note dated January 2009 entitled 'Changes We Have Made to the CLEA Framework Documents' ⁽⁸⁾
	1	To provide SAC for sites where SOM <6% as often observed by RSK
	2.5	
pH	7	Model default

Table 2
Residential with Private Gardens –Homegrown Produce Data for CLEA Model

	Consumption Rate (g FW kg ⁻¹ BW day ⁻¹) by Age Class						Dry Weight Conversion Factor	Homegrown Fraction (average)	Homegrown Fraction (high end)	Soil loading factor	Preparation correction factor
Name	1	2	3	4	5	6	g DW g ⁻¹ FW	-	-	g g ⁻¹ DW	-
Green vegetables	7.12	6.85	6.85	6.85	3.74	3.74	0.096	0.05	0.33	1.00E-03	2.00E-01
Root vegetables	10.69	3.30	3.30	3.30	1.77	1.77	0.103	0.06	0.4	1.00E-03	1.00E+00
Tuber vegetables	16.03	5.46	5.46	5.46	3.38	3.38	0.21	0.02	0.13	1.00E-03	1.00E+00
Herbaceous fruit	1.83	3.96	3.96	3.96	1.85	1.85	0.058	0.06	0.4	1.00E-03	6.00E-01
Shrub fruit	2.23	0.54	0.54	0.54	0.16	0.16	0.166	0.09	0.6	1.00E-03	6.00E-01
Tree fruit	3.82	11.96	11.96	11.96	4.26	4.26	0.157	0.04	0.27	1.00E-03	6.00E-01
Justification	Table 4.17, SR3 ⁽³⁾						Table 6.3, SR3 ⁽³⁾	Table 4.19, SR3 ⁽³⁾		Table 6.3, SR3 ⁽³⁾	

Table 3
Residential with Private Gardens – Land Use Data for CLEA Model

Parameter	Unit	Age Class					
		1	2	3	4	5	6
EF (soil and dust ingestion)	day yr ⁻¹	180	365	365	365	365	365
EF (consumption of homegrown produce)	day yr ⁻¹	180	365	365	365	365	365
EF (skin contact, indoor)	day yr ⁻¹	180	365	365	365	365	365
EF (skin contact, outdoor)	day yr ⁻¹	180	365	365	365	365	365
EF (inhalation of dust and vapour, indoor)	day yr ⁻¹	365	365	365	365	365	365
EF (inhalation of dust and vapour, outdoor)	day yr ⁻¹	365	365	365	365	365	365
Justification		Table 3.1, SR3 ⁽³⁾					
Occupancy period (indoor)	hr day ⁻¹	23	23	23	23	19	19
Occupancy period (outdoor)	hr day ⁻¹	1	1	1	1	1	1
Justification		Table 3.2, SR3 ⁽³⁾					
Soil to skin adherence factor (indoor)	mg cm ⁻² day ⁻¹	6.00E-02	6.00E-02	6.00E-02	6.00E-02	6.00E-02	6.00E-02
Soil to skin adherence factor (outdoor)	mg cm ⁻² day ⁻¹	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Justification		Table 8.1, SR3 ⁽³⁾					
Soil and dust ingestion rate	g day ⁻¹	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
Justification		Table 6.2, SR3 ⁽³⁾					

Of note, for **cadmium**, the exposure assessment for a residential land use is based on estimates representative of lifetime exposure AC1-18. This is because the TDI_{oral} and TDI_{inh} – are based on considerations of the kidney burden accumulated over 50 years. It is therefore reasonable to consider exposure not only in childhood but averaged over a longer time period. See the Environment Agency Science report: SC05002 / TOX 3⁽¹⁾ and Science Report SC050021 / Cadmium SGV⁽¹⁾ for more information.

Table 4
Residential with Private Gardens – Receptor Data for CLEA Model

Parameter	Unit	Age Class						Justification
		1	2	3	4	5	6	
Body weight	kg	5.6	9.8	12.7	15.1	16.9	19.7	Table 4.6, SR3 ⁽³⁾
Body height	m	0.7	0.8	0.9	0.9	1	1.1	
Inhalation rate	m ³ day ⁻¹	8.5	13.3	12.7	12.2	12.2	12.2	Table 4.14, SR3 ⁽³⁾
Max exposed skin fraction (indoor)	m ² m ⁻²	0.32	0.33	0.32	0.35	0.35	0.33	Table 4.8, SR3 ⁽³⁾
Max exposed skin fraction (outdoor)	m ² m ⁻²	0.26	0.26	0.25	0.28	0.28	0.26	

See **cadmium** note as per Table 3 above.

Table 5
Residential with Private Gardens – Soil and Building Inputs for CLEA Model

Parameter	Unit	Value	Justification
SOIL PROPERTIES for sandy loam			
Porosity, total	cm ³ cm ⁻³	0.53	Default soil type is sandy loam, section 4.3.1, SR3 ⁽³⁾ Parameters for sandy loam from Table 4.4, SR3 ⁽³⁾
Porosity, air filled	cm ³ cm ⁻³	0.20	
Porosity, water filled	cm ³ cm ⁻³	0.33	
Residual soil water content	cm ³ cm ⁻³	0.12	
Saturated hydraulic conductivity	cm s ⁻¹	3.56E-03	
van Genuchten shape parameter (m)	-	3.20E-01	
Bulk density	g cm ⁻³	1.21	Default value taken from Section 9.2.2, SR3 ⁽³⁾
Threshold value of wind speed at 10m	m s ⁻¹	7.20	
Empirical function (F _x) for dust model	-	1.22	
Ambient soil temperature	K	283	Annual average soil temperature representative of UK surface soils. Section 4.3.1, SR3 ⁽³⁾
AIR DISPERSION MODEL			
Mean annual wind speed (10 m)	m s ⁻¹	5.00	Default value taken from Section 9.2.2, SR3 ⁽³⁾
Air dispersion factor at height of 0.8 m	g m ⁻² s ⁻¹ per kg m ⁻³	2400	Values for a 0.01 ha site, appropriate to a residential land use in Newcastle (most representative city for UK). (from Table 9.1, SR3 ⁽³⁾) Assumed child of 6 is not tall enough to reach 1.6m
Air dispersion factor at height of 1.6 m	g m ⁻² s ⁻¹ per kg m ⁻³	0	
Fraction of site with hard or vegetative cover	m ² m ⁻²	0.75	Section 3.2.6, SR3 ⁽³⁾ based on residential land use
BUILDING PROPERTIES for small terrace house with ground-bearing floor slab			
Building footprint	m ²	28	From Table 3.3 and 4.21, SR3 ⁽³⁾
Living space air exchange rate	hr ⁻¹	0.50	
Living space height (above ground)	m	4.8	
Living space height (below ground)	m	0.0	Assumed no basement
Pressure difference (soil to enclosed space)	Pa	3.1	From Table 3.3, SR3 ⁽³⁾
Foundation thickness	m	0.15	
Floor crack area	cm ²	423	
Dust loading factor	µg m ⁻³	50	Default value for a residential site taken from Section 9.3, SR3 ⁽³⁾
VAPOUR MODEL			
Default soil gas ingress rate	cm ³ s ⁻¹	25	Generic flow rate, Section 10.3, SR3 ⁽³⁾
Depth to top of source (beneath building)	cm	50	Section 3.2.6, SR3 ⁽³⁾ states source is 50cm below building or 65cm below ground surface
Depth to top of source (no building)	cm	0	Section 10.2, SR3 ⁽³⁾ assumes impact from 0-1m for outdoor inhalation pathway
Thickness of contaminant layer	cm	200	Model default for indoor air, Section 4.9, SR4 ⁽⁴⁾
Time average period for surface emissions	years	6	Time period of a 0 to 6 year old, Box 3.5, SR3 ⁽³⁾
User-defined effective air permeability	cm ²	3.05E-08	Calculated for sandy loam using equations in Appendix 1, SR3 ⁽³⁾

Figure 2
GrAC Conceptual Model for RBCA Residential with Private Gardens
Scenario

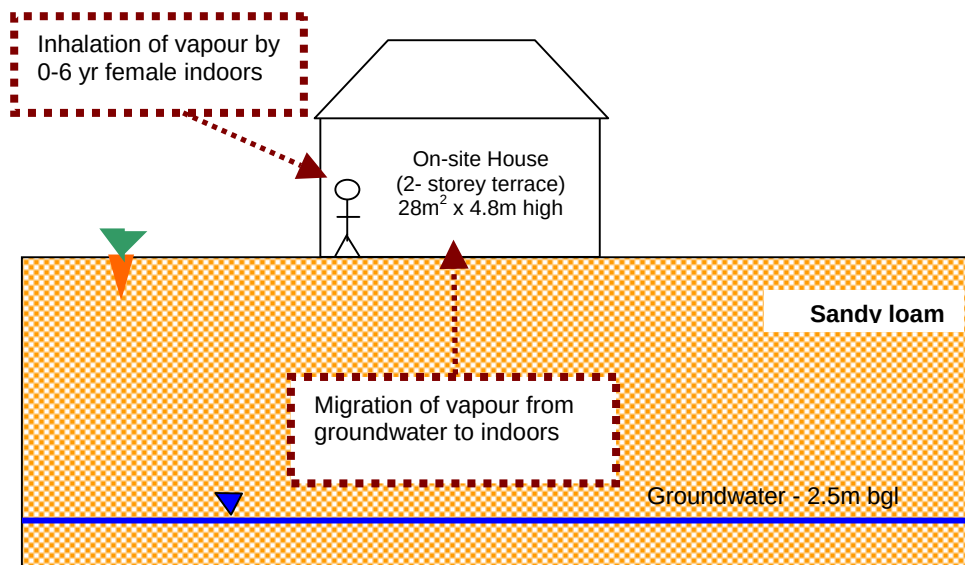


Table 6
Residential with Private Gardens RBCA Inputs

Parameter	Unit	Value	Justification
RECEPTOR			
Averaging time	Years	6	From Box 3.1, SR3 ⁽³⁾
Receptor weight	kg	13.3	Average of CLEA 0-6 year old female data, Table 4.6, SR3 ⁽³⁾
Exposure duration	Years	6	From Box 3.1, report , SR3 ⁽³⁾
Exposure frequency	Days/yr	350	Weighted using occupancy period of 23 hours per day for 365 days of the year
SOIL TYPE – SANDY LOAM			
Total porosity	-	0.53	CLEA value for sandy loam. Parameters for sandy loam from Table 4.4, SR3 ⁽³⁾
Volumetric water content	-	0.33	
Volumetric air content	-	0.20	
Dry bulk density	g cm ⁻³	1.21	
Vertical hydraulic conductivity	cm s ⁻¹	3.56E-3	CLEA value for saturated conductivity of sandy loam, Table 4.4, SR3 ⁽³⁾
Vapour permeability	m ²	3.05E-12	Calculated for sandy loam using equations in Appendix 1, SR3 ⁽³⁾
Capillary zone thickness	m	0.1	Professional judgement
Fraction organic carbon	%	(i) 0.0348	Representative of sandy loam according to EA Guidance note dated January 2009 entitled Changes We Have Made to the CLEA Framework Documents (ref)
		(ii) 0.0058	To provide SAC for site's where SOM < 6% as often observed by RSK
BUILDING			
Building volume/area ratio	m	4.8	Table 3.3, SR3 ⁽³⁾
Foundation area	m ²	28	
Foundation perimeter	m	22	Calculated assuming building measures 7m x 4m to give 28m ² foundation area
Building air exchange rate	d ⁻¹	12	Table 3.3, SR3 ⁽³⁾
Depth to bottom of foundation slab	m	0.15	
Foundation thickness	m	0.15	
Foundation crack fraction	-	0.0151	Calculated from floor crack area of 423 cm ² and building footprint of 28m ² in Table 4.21, SR3 ⁽³⁾
Volumetric water content of cracks	-	0.33	Assumed equal to underlying soil type in assumption that cracks become filled with soil over time. Parameters for sandy loam from Table 4.4, SR3 ⁽³⁾
Volumetric air content of cracks	-	0.2	
Indoor/outdoor differential pressure	Pa	3.1	From Table 3.3, SR3 ⁽³⁾

Table 7

Human Health Generic Assessment Criteria by Pathway for Residential Scenario - Private Gardens

Compound	Notes	GrAC (mg/l)	SAC Appropriate to Pathway SOM 1% (mg/kg)			Soil Saturation Limit (mg/kg)	SAC Appropriate to Pathway SOM 2.5% (mg/kg)			Soil Saturation Limit (mg/kg)	SAC Appropriate to Pathway SOM 6% (mg/kg)			Soil Saturation Limit (mg/kg)
			Oral	Inhalation	Combined		Oral	Inhalation	Combined		Oral	Inhalation	Combined	
Metals														
Arsenic	(b)(c)	-	3.24E+01	8.50E+01	-	NR	3.24E+01	8.50E+01	-	NR	3.24E+01	8.50E+01	-	NR
Cadmium	(b)	-	1.12E+01	1.85E+02	1.10E+01	NR	1.12E+01	1.85E+02	1.10E+01	NR	1.12E+01	1.85E+02	1.10E+01	NR
Chromium (III) - oxide		-	1.84E+04	3.55E+03	2.98E+03	NR	1.84E+04	3.55E+03	2.98E+03	NR	1.84E+04	3.55E+03	2.98E+03	NR
Chromium (VI) - hexavalent		-	1.02E+01	4.25E+00	3.21E+00	NR	1.02E+01	4.25E+00	3.21E+00	NR	1.02E+01	4.25E+00	3.21E+00	NR
Copper		-	2.66E+03	1.04E+04	2.33E+03	NR	2.66E+03	1.04E+04	2.33E+03	NR	2.66E+03	1.04E+04	2.33E+03	NR
Lead	(a)	-	4.50E+02	-	-	NR	4.50E+02	-	-	NR	4.50E+02	-	-	NR
Elemental Mercury (Hg ⁰)	(b)(d)	9.40E-03	-	1.70E-01	-	4.31E+00	-	4.24E-01	-	1.07E+01	-	1.02E+00	-	2.58E+01
Inorganic Mercury (Hg ²⁺)	(b)	-	1.81E+02	2.55E+03	1.69E+02	NR	1.81E+02	2.55E+03	1.69E+02	NR	1.81E+02	2.55E+03	1.69E+02	NR
Methyl Mercury (Hg ⁴⁺)	(b)	2.00E+01	1.39E+01	1.59E+01	7.40E+00	7.33E+01	1.39E+01	3.08E+01	9.55E+00	1.42E+02	1.39E+01	6.53E+01	1.14E+01	3.04E+02
Nickel	(b)(d)	-	5.31E+02	1.27E+02	-	NR	5.31E+02	1.27E+02	-	NR	5.31E+02	1.27E+02	-	NR
Selenium	(b)(c)	-	3.50E+02	-	-	NR	3.50E+02	NR	-	NR	3.50E+02	-	-	NR
Zinc	(c)	-	3.75E+03	2.55E+07	-	NR	3.75E+03	2.55E+07	-	NR	3.75E+03	2.55E+07	-	NR
Cyanide		-	2.66E+01	3.97E+00	3.68E+00	NR	2.66E+01	3.97E+00	3.68E+00	NR	2.66E+01	3.97E+00	3.68E+00	NR
Volatile Organic Compounds														
Benzene	(b)	7.20E+00	1.12E-01	2.69E-01	7.92E-02	1.22E+03	2.28E-01	4.99E-01	1.57E-01	2.26E+03	4.89E-01	1.04E+00	3.32E-01	4.71E+03
Toluene	(b)	1.90E+03	1.47E+02	6.26E+02	1.19E+02	8.69E+02	3.35E+02	1.38E+03	2.70E+02	1.92E+03	7.59E+02	3.14E+03	6.11E+02	4.36E+03
Ethylbenzene	(b)	2.60E+02	1.06E+02	1.70E+02	6.52E+01	5.18E+02	2.51E+02	3.98E+02	1.54E+02	1.22E+03	5.70E+02	9.32E+02	3.54E+02	2.84E+03
Xylene - m	(b)	8.40E+01	2.02E+02	5.56E+01	4.36E+01	6.25E+02	4.80E+02	1.31E+02	1.03E+02	1.47E+03	1.09E+03	3.07E+02	2.40E+02	3.46E+03
Xylene - o		1.00E+02	1.85E+02	5.98E+01	4.52E+01	4.78E+02	4.38E+02	1.40E+02	1.06E+02	1.12E+03	9.96E+02	3.27E+02	2.46E+02	2.62E+03
Xylene - p		8.70E+01	1.91E+02	5.34E+01	4.17E+01	5.76E+02	4.51E+02	1.26E+02	9.82E+01	1.35E+03	1.02E+03	2.94E+02	2.28E+02	3.17E+03
Total xylene		8.40E+01	2.02E+02	5.56E+01	4.36E+01	6.25E+02	4.80E+02	1.31E+02	1.03E+02	1.47E+03	1.09E+03	3.07E+02	2.40E+02	3.46E+03
Methyl t-Butyl ether		2.20E+03	1.75E+00	1.84E+02	1.75E+00	1.66E+04	3.68E+00	2.40E+02	3.67E+00	2.16E+04	7.41E+00	3.70E+02	7.37E+00	3.34E+04
Trichloroethene		1.80E+00	2.83E+00	1.10E-01	1.06E-01	1.54E+03	6.25E+00	2.30E-01	2.22E-01	3.22E+03	1.40E+01	5.11E-01	4.93E-01	7.14E+03
Tetrachloroethene		3.60E+00	1.06E+01	1.03E+00	9.36E-01	4.24E+02	2.44E+01	2.30E+00	2.10E+00	9.51E+02	5.55E+01	5.28E+00	4.82E+00	2.18E+03
1,1,1-Trichloroethane		2.60E+01	3.20E+02	6.33E+00	6.21E+00	1.43E+03	6.97E+02	1.29E+01	1.27E+01	2.92E+03	1.55E+03	2.84E+01	2.79E+01	6.39E+03
1,1,1,2-Tetrachloroethane		1.40E+01	5.19E+00	1.08E+00	8.93E-01	2.60E+03	1.22E+01	2.50E+00	2.08E+00	6.02E+03	2.78E+01	5.83E+00	4.82E+00	1.40E+04
1,1,2,2-Tetrachloroethane		1.40E+01	2.70E+00	2.76E+00	1.37E+00	2.67E+03	5.85E+00	5.65E+00	2.87E+00	5.46E+03	1.30E+01	1.24E+01	6.34E+00	1.20E+04
Carbon Tetrachloride		5.50E-02	1.05E+00	1.81E-02	1.79E-02	1.52E+03	2.41E+00	3.97E-02	3.93E-02	3.32E+03	5.44E+00	8.99E-02	8.92E-02	7.54E+03
1,2-Dichloroethane		3.00E-01	3.06E-02	6.46E-03	5.34E-03	3.41E+03	5.53E-02	9.32E-03	7.98E-03	4.91E+03	1.05E-01	1.60E-02	1.39E-02	8.43E+03
Vinyl Chloride		1.90E-02	3.69E-03	5.43E-04	4.73E-04	1.36E+03	6.64E-03	7.02E-04	6.35E-04	1.76E+03	1.21E-02	1.07E-03	9.86E-04	2.69E+03
1,2,4-Trimethylbenzene		7.50E-02	-	3.51E-01	-	5.57E+02	-	8.55E-01	-	1.36E+03	-	2.10E+00	-	3.25E+03
1,3,5-Trimethylbenzene		4.70E-02	1.45E+01	4.60E-01	4.56E-01	9.47E+01	3.47E+01	1.10E+00	1.09E+00	2.26E+02	7.94E+01	2.59E+00	2.56E+00	5.33E+02
Semi-Volatile Organic Compounds														
Acenaphthene		3.20E+00	2.18E+02	3.46E+03	2.05E+02	5.70E+01	5.08E+02	8.54E+03	4.79E+02	1.41E+02	1.06E+03	2.03E+04	1.01E+03	3.36E+02
Acenaphthylene		4.20E+00	1.78E+02	3.27E+03	1.68E+02	8.61E+01	4.17E+02	8.03E+03	3.97E+02	2.12E+02	8.90E+02	1.91E+04	8.51E+02	5.06E+02
Anthracene		2.10E-02	2.31E+03	1.08E+05	2.26E+03	1.17E+00	5.03E+03	2.65E+05	4.93E+03	2.91E+00	9.33E+03	6.15E+05	9.19E+03	6.96E+00
Benzo(a)anthracene		3.80E-03	7.00E+00	5.55E+00	3.10E+00	1.71E+00	8.98E+00	9.83E+00	4.69E+00	4.28E+00	1.01E+01	1.41E+01	5.88E+00	1.03E+01
Benzo(b)fluoranthene		2.00E-03	8.06E+00	1.79E+01	5.56E+00	1.22E+00	9.78E+00	1.97E+01	6.53E+00	3.04E+00	1.07E+01	2.05E+01	7.02E+00	7.29E+00
Benzo(g,h,i)perylene		2.60E-04	6.68E+01	1.27E+02	4.38E+01	1.54E-02	7.04E+01	1.32E+02	4.59E+01	3.85E-02	7.19E+01	1.34E+02	4.68E+01	9.23E-02
Benzo(k)fluoranthene		8.00E-04	1.25E+01	2.66E+01	8.51E+00	6.87E-01	1.44E+01	2.83E+01	9.56E+00	1.72E+00	1.53E+01	2.91E+01	1.00E+01	4.12E+00
Chrysene		2.00E-03	8.76E+00	1.95E+01	6.00E+00	4.40E-01	1.20E+01	2.45E+01	8.04E+00	1.10E+00	1.41E+01	2.72E+01	9.27E+00	2.64E+00
Dibenzo(a,h)anthracene		6.00E-04	1.19E+00	2.13E+00	7.62E-01	3.93E-03	1.33E+00	2.42E+00	8.58E-01	9.82E-03	1.39E+00	2.56E+00	9.03E-01	2.36E-02
Fluoranthene		2.30E-01	2.59E+02	2.69E+04	2.57E+02	1.89E+01	4.67E+02	6.23E+04	4.63E+02	4.73E+01	6.78E+02	1.28E+05	6.74E+02	1.13E+02
Fluorene		1.90E+00	1.70E+02	4.35E+03	1.63E+02	3.09E+01	3.91E+02	1.07E+04	3.77E+02	7.65E+01	8.00E+02	2.54E+04	7.76E+02	1.83E+02
Indeno(1,2,3-cd)pyrene		2.00E-04	4.58E+00	1.04E+01	3.18E+00	6.13E-02	5.74E+00	1.17E+01	3.85E+00	1.53E-01	6.37E+00	1.22E+01	4.19E+00	3.68E-01
Phenanthrene		5.30E-01	9.35E+01	5.04E+03	9.18E+01	3.60E+01	2.04E+02	1.23E+04	2.01E+02	8.96E+01	3.81E+02	2.86E+04	3.76E+02	2.14E+02
Pyrene		1.30E-01	5.69E+02	6.18E+04	5.63E+02	2.20E+00	1.05E+03	1.44E+05	1.04E+03	5.49E+00	1.56E+03	2.97E+05	1.56E+03	1.32E+01
Benzo(a)pyrene		3.80E-03	1.21E+00	2.62E+00	8.26E-01	9.11E-01	1.42E+00	2.81E+00	9.43E-01	2.28E+00	1.52E+00	2.90E+00	9.98E-01	5.46E+00
Naphthalene		1.90E+01	2.68E+01	1.64E+00	1.54E+00	7.64E+01	6.36E+01	3.93E+00	3.70E+00	1.83E+02	1.43E+02	9.27E+00	8.71E+00	4.32E+02
Phenol	(b)	-	4.51E+02	3.11E+02	1.84E+02	4.16E+04	9.38E+02	4.20E+02	2.90E+02	8.15E+04	2.04E+03	5.21E+02	4.15E+02	1.74E+05

Table 7

Human Health Generic Assessment Criteria by Pathway for Residential Scenario - Private Gardens

Compound	Notes	GrAC (mg/l)	SAC Appropriate to Pathway SOM 1% (mg/kg)			Soil Saturation Limit (mg/kg)	SAC Appropriate to Pathway SOM 2.5% (mg/kg)			Soil Saturation Limit (mg/kg)	SAC Appropriate to Pathway SOM 6% (mg/kg)			Soil Saturation Limit (mg/kg)
			Oral	Inhalation	Combined		Oral	Inhalation	Combined		Oral	Inhalation	Combined	
Total Petroleum Hydrocarbons														
Aliphatic hydrocarbons EC ₆ -EC ₆		1.00E+01	4.79E+03	2.98E+01	2.97E+01	3.04E+02	1.08E+04	5.47E+01	5.46E+01	5.58E+02	2.35E+04	1.13E+02	1.13E+02	1.15E+03
Aliphatic hydrocarbons >EC ₆ -EC ₈		5.40E+00	1.43E+04	7.27E+01	7.26E+01	1.44E+02	3.21E+04	1.62E+02	1.62E+02	3.22E+02	6.36E+04	3.72E+02	3.71E+02	7.36E+02
Aliphatic hydrocarbons >EC ₈ -EC ₁₀		2.30E-01	1.46E+03	1.89E+01	1.88E+01	7.77E+01	2.44E+03	4.60E+01	4.58E+01	1.90E+02	3.30E+03	1.09E+02	1.08E+02	4.51E+02
Aliphatic hydrocarbons >EC ₁₀ -EC ₁₂		3.40E-02	3.52E+03	9.34E+01	9.28E+01	4.75E+01	4.01E+03	2.32E+02	2.29E+02	1.18E+02	4.24E+03	5.57E+02	5.37E+02	2.83E+02
Aliphatic hydrocarbons >EC ₁₂ -EC ₁₆		7.60E-04	4.37E+03	7.82E+02	7.44E+02	2.37E+01	4.40E+03	1.95E+03	1.69E+03	5.91E+01	4.41E+03	4.68E+03	3.03E+03	1.42E+00
Aliphatic hydrocarbons >EC ₁₆ -EC ₃₅	(c)	-	4.51E+04	-	-	8.48E+00	6.38E+04	-	-	2.12E+01	7.61E+04	-	-	5.09E+01
Aliphatic hydrocarbons >EC ₃₅ -EC ₄₄	(c)	-	4.51E+04	-	-	8.48E+00	6.38E+04	-	-	2.12E+01	7.61E+04	-	-	5.09E+01
Aromatic hydrocarbons >EC ₈ -EC ₉ (styrene)		7.40E+00	1.66E+02	2.65E+02	1.33E+02	6.20E+02	3.92E+02	6.47E+02	3.16E+02	1.52E+03	8.50E+02	1.54E+03	7.02E+02	3.61E+03
Aromatic hydrocarbons >EC ₉ -EC ₁₀		7.40E+00	5.55E+01	3.33E+01	2.69E+01	6.13E+02	1.31E+02	8.16E+01	6.54E+01	1.50E+03	2.84E+02	1.94E+02	1.51E+02	3.58E+02
Aromatic hydrocarbons >EC ₁₀ -EC ₁₂		2.50E+01	7.97E+01	1.82E+02	6.91E+01	3.64E+02	1.86E+02	4.48E+02	1.62E+02	8.99E+02	3.87E+02	1.07E+03	3.46E+02	2.15E+03
Aromatic hydrocarbons >EC ₁₂ -EC ₁₆		5.80E+00	1.40E+02	2.00E+03	1.38E+02	1.69E+02	3.13E+02	4.96E+03	3.08E+02	4.19E+02	6.01E+02	1.18E+04	5.93E+02	1.00E+03
Aromatic hydrocarbons >EC ₁₆ -EC ₂₁	(c)	-	2.47E+02	-	-	5.37E+01	4.82E+02	-	-	1.34E+02	7.66E+02	-	-	3.21E+02
Aromatic hydrocarbons >EC ₂₁ -EC ₃₅	(c)	-	8.88E+02	-	-	4.83E+00	1.11E+03	-	-	1.21E+01	1.22E+03	-	-	2.90E+01
Aromatic hydrocarbons >EC ₃₅ -EC ₄₄	(c)	-	8.88E+02	-	-	4.83E+00	1.11E+03	-	-	1.21E+01	1.22E+03	-	-	2.90E+01

Notes:

'-' Generic assessment criteria not calculated owing to low volatility of substance and therefore no pathway, or an absence of toxicological data.

NR - the compound is not volatile and therefore a soil saturation limit not calculated within CLEA

EC - equivalent carbon. GrAC - groundwater assessment criteria. SAC - soil assessment criteria.

The CLEA model output is colour coded depending upon whether the soil saturation limit has been exceeded.

	Calculated SAC exceeds soil saturation limit and may significantly effect the interpretation of any exceedances since the contribution of the indoor and outdoor vapour pathway to total exposure is >10%. This shading has also been used for the RBCA output where the theoretical solubility limit has been exceeded. The SAC has been set as the model calculated SAC with the saturation limits shown in brackets.
	Calculated SAC exceeds soil saturation limit but will not effect the SSV significantly since the contribution of the indoor and outdoor vapour pathway to total exposure is <10%.
	Calculated SAC does not exceed the soil saturation limit.

For consistency where the theoretical solubility limit within RBCA has been exceeded in production of the GrAC, these cells have also been hatched red.

The SAC for organic compounds are dependant upon soil organic matter (SOM) (%) content. To obtain SOM from total organic carbon (TOC) (%) divide by 0.58. 1% SOM is 0.58% TOC. DL Rowell Soil Science: Methods and Applications, Longmans, 1994.

SAC for TPH fractions, polycyclic aromatic hydrocarbons, MTBE, BTEX and trimethylbenzene compounds were produced using an attenuation factor for the indoor air inhalation pathway of 10 to reduce conservatism associated with the vapour inhalation pathway, section 10.1.1, SR3

(a) GAC taken as former Soil Guideline Value owing to uncertainty regarding toxicological approach to be adopted by the Environment Agency.

(b) GAC taken from the Environment Agency SGV reports published 2009.

(c) SAC for selenium, aliphatic and aromatic hydrocarbons $>EC_{16}$ does not include inhalation pathway owing to absence of toxicity data. SAC for arsenic is only based on oral contribution (rather than combined) owing to the relative small contribution from inhalation in accordance with the SGV report. The same approach has been adopted for zinc.

(d) SAC for elemental mercury, chromium VI and nickel is based on the inhalation pathway only owing to an absence of toxicity for elemental mercury, in accordance with the SGV report for nickel and LQM report for chromium VI.

Table 8
Human Health Generic Assessment Criteria for Residential Scenario - Private Gardens

Compound	GrAC for Groundwater (mg/l)	SAC for Soil SOM 1% (mg/kg)	SAC for Soil SOM 2.5% (mg/kg)	SAC for Soil SOM 6% (mg/kg)
Metals				
Arsenic	-	32	32	32
Cadmium	-	10	10	10
Chromium (III) - oxide	-	3,000	3,000	3,000
Chromium (VI) - hexavalent	-	4.3	4.3	4.3
Copper	-	2,300	2,300	2,300
Lead	-	450	450	450
Elemental Mercury (Hg ⁰)	0.009	0.17	0.42	1.0
Inorganic Mercury (Hg ²⁺)	-	170	170	170
Methyl Mercury (Hg ⁴⁺)	20	7.4	9.6	11
Nickel	-	130	130	130
Selenium	-	350	350	350
Zinc	-	3,800	3,800	3,800
Cyanide	-	3.7	3.7	3.7
Volatile Organic Compounds				
Benzene	7	0.079	0.157	0.33
Toluene	1,900	120	270	610
Ethylbenzene	260	65	154	350
Xylene - m	100	44	103	240
Xylene - o	87	45	106	250
Xylene - p	84	42	98	230
Total xylene	84	44	103	240
Methyl tertiary butyl ether (MTBE)	2,200	1.8	3.7	7.4
Trichloroethene	1.8	0.11	0.2	0.49
Tetrachloroethene	3.6	0.94	2.1	4.8
1,1,1-Trichloroethane	26	6.2	12.7	28
1,1,1,2-Tetrachloroethane	14	0.89	2.1	4.8
1,1,2,2-Tetrachloroethane	14	1.4	2.87	6.3
Carbon Tetrachloride	0.055	0.018	0.039	0.089
1,2-Dichloroethane	0.30	0.0053	0.0080	0.014
Vinyl Chloride	0.019	0.00047	0.0006	0.001
1,2,4-Trimethylbenzene	0.075	0.35	0.85	2.1
1,3,5-Trimethylbenzene	0.047	0.46	1.1	2.6
Semi-Volatile Organic Compounds				
Acenaphthene	3.2	210	480	1,000
Acenaphthylene	4.2	170	400	850
Anthracene	0.021	2,300	4,900	9,200
Benzo(a)anthracene	0.0038	3.1	4.7	5.9
Benzo(b)fluoranthene	0.0020	5.6	6.5	7.0
Benzo(g,h,i)perylene	0.00026	44	46	47
Benzo(k)fluoranthene	0.00080	8.5	9.6	10
Chrysene	0.0020	6.0	8.0	9.3
Dibenzo(a,h)anthracene	0.00060	0.76	0.86	0.90
Fluoranthene	0.23	260	460	670
Fluorene	1.9	160	380	780
Indeno(1,2,3-cd)pyrene	0.0002	3.2	3.8	4.2
Phenanthrene	0.53	92	200	380
Pyrene	0.13	560	1,000	1,600
Benzo(a)pyrene	0.0038	0.83	0.94	1.0
Naphthalene	19	1.5	3.7	8.7
Phenol	-	180	290	420
Total Petroleum Hydrocarbons				
Aliphatic hydrocarbons EC ₅ -EC ₆	10	30	55	110
Aliphatic hydrocarbons >EC ₆ -EC ₉	5.4	73	160	370
Aliphatic hydrocarbons >EC ₉ -EC ₁₀	0.23	19	46	110
Aliphatic hydrocarbons >EC ₁₀ -EC ₁₂	0.034	93 (48)	230 (118)	540 (283)
Aliphatic hydrocarbons >EC ₁₂ -EC ₁₆	0.00076	744 (24)	1,700 (59)	3,000 (142)
Aliphatic hydrocarbons >EC ₁₆ -EC ₃₅	-	45,100 (8.48)	64,000 (21)	76,000
Aliphatic hydrocarbons >EC ₃₅ -EC ₄₄	-	45,100 (8.48)	64,000 (21)	76,000
Aromatic hydrocarbons >EC ₉ -EC ₉ (styrene)	7.4	130	316	700
Aromatic hydrocarbons >EC ₉ -EC ₁₀	7.4	27	65	150
Aromatic hydrocarbons >EC ₁₀ -EC ₁₂	25	69	160	346
Aromatic hydrocarbons >EC ₁₂ -EC ₁₆	5.8	140	310	593
Aromatic hydrocarbons >EC ₁₆ -EC ₂₁	-	250	480	770
Aromatic hydrocarbons >EC ₂₁ -EC ₃₅	-	890	1,100	1,230
Aromatic hydrocarbons >EC ₃₅ -EC ₄₄	-	890	1,100	1,230

Notes:

‘-’ Generic assessment criteria not calculated owing to low volatility of substance and therefore no pathway, or an absence of toxicological data.

EC - equivalent carbon. GrAC - groundwater assessment criteria. SAC - soil assessment criteria.

The SAC for organic compounds are dependent on Soil Organic Matter (SOM) (%) content. To obtain SOM from total organic carbon (TOC) (%) divide by 0.58.
1% SOM is 0.58% TOC. DL Rowell Soil Science: Methods and Applications, Longmans, 1994.

SAC for TPH fractions, polycyclic aromatic hydrocarbons, MTBE, BTEX and trimethylbenzene compounds were produced using an attenuation factor for the indoor air inhalation pathway of 10 to reduce conservatism associated with the vapour inhalation pathway, section 10.1.1, SR3.

The SAC has been set as the model calculated SAC with the saturation limit shown in brackets.
For consistency where the GrAC exceeds the solubility limit, GrAC has been set at the solubility limit. The GrAC is conservative since concentrations of the chemical are very unlikely to be at sufficient concentration to result in an exceedance of the health criteria value at the point of exposure (i.e. indoor air) provided free-phase product is absent.

REFERENCES

- 1) Environment Agency, 31 March 2009, May 2009 and September 2009. Science Report SC050021 / benzene SGV, toluene SGV, ethylbenzene SGV, xylene SGV, mercury SGV, selenium SGV, nickel SGV, arsenic SGV, cadmium SGV, phenol SGV, dioxins, furans and dioxinlike PCBs SGVs. Supplementary information for the derivation of SGV for: benzene, toluene, ethylbenzene, xylene, mercury, selenium, nickel, arsenic, cadmium, phenol, dioxins, furans and dioxin-like PCBs. Contaminants in soil: updated collation of toxicological data and intake values for humans: benzene, toluene, ethylbenzene, xylene, mercury, selenium, nickel, arsenic, cadmium, phenol, dioxins, furans and dioxin-like PCBs.
- 2) Environment Agency, January 2009. Science Report SC050021/SR2 Human Health Toxicological Assessment of Contaminants in Soil.
- 3) Environment Agency, January 2009. Science Report SC050021/SR3 Updated Technical Background to the CLEA Model.
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- 5) Environment Agency. 2008. Science Report SC050021/SR7. Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values.
- 6) Land Quality Management (LQM) and Chartered Institute of Environmental Health (CIEH) 2009. The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment. 2nd Edition.
- 7) The Soil Generic Assessment Criteria for Human Health Risk Assessment, Report ref. ISBN 978-1-905046-20-1, December 2009, published by CL:AIRE
- 8) Changes made to the CLEA framework documents after the 3 month evaluation period in 2008, released January 2009 by the Environment Agency.

APPENDIX I

Generic Assessment Criteria for Controlled Waters

GENERIC ASSESSMENT CRITERIA FOR PHYTOTOXIC EFFECTS, PIPELINES AND CONTROLLED WATERS

This appendix presents the generic assessment criteria (GAC) that RSK considers are suitable for assessing risks to:

- Vegetation via the uptake of phytotoxic determinants through plant roots;
- Water supply pipes constructed using conventional pipe materials, i.e. polyethylene; and
- Controlled waters.

The GAC for each of these receptors is discussed in turn.

PHYTOTOXIC DETERMINANTS TO FACILITATE HEALTHY PLANT GROWTH

Copper and zinc can inhibit plant growth but are not normally hazardous to human health. The GAC for this pollutant linkage have been taken from Department of the Environment Publication, Code of Practice for Agricultural Use of Sewage Sludge, 1996. The GAC for the phytotoxic determinants are presented in Table A1. The table also includes nickel since this is also phytotoxic determinant and the Soil Guideline Value (SGV which is protective of human health) for a commercial (5000mg/kg) or residential without plant uptake (75mg/kg) is greater than the GAC to protect plant growth in acidic soil. Therefore, the SGV may not be suitably protective of the phytotoxic effects pathway.

Table A1: Generic Assessment Criteria for Phytotoxic Determinants

Determinant	Generic Assessment Criteria (mg/kg)			
	pH 5.0 < 5.5	pH 5.5 < 6.0	pH 6.0 < 7.0	pH >7.0
Zinc	200	200	200	300
Copper	80	100	135	200
Nickel	50	60	75	110

WATER SUPPLY PIPES

Risks to water supply pipes have been assessed in accordance with the Water Regulations Advisory Scheme Information and Guidance Note 9-04-03, dated October 2002.

The regulations include a requirement to use only suitable materials when laying water pipes and laying water pipes without protection is not permitted at contaminated sites. The water supplier has a statutory duty to enforce the regulations. Therefore, this assessment is a guide, the results of which should be checked with the water supplier.

Since water supply pipes are typically laid at a minimum depth of 750mm below finished ground levels, sample results from depths between 0.5m and 1.5m below finished level are generally considered suitable for assessing risks to water supply. Samples outside these depths can be used providing the strata is the same as that in which water supply pipes are likely to be located.

The GAC for this linkage are recorded in Table A2 and are based on recommendations of the 'Foundation for Water Research Guidance Note, FR0448: Laying Potable Water Pipelines in Contaminated Ground, 1994'. Owing to the number of caveats and lack of research into contaminants that could affect water supply, the water industry has undertaken research on a project entitled 'Pipe Materials Selection and Specification for use in Contaminated Land'. This document will be used to update the GAC for this pathway once available.

Table A2: Generic Assessment Criteria for Water Supply Pipes

CONTAMINANT	GAC (mg/kg dried soil)
Corrosion	
Sulphate	2000
Sulphur	5000
Sulphide	250
pH	Less than pH5 Greater than pH8
Toxic Substances	
Antimony	10
Arsenic	10*
Cadmium	3
Chromium (hexavalent)	25
Chromium (total)	600
Cyanide (free)	25*
Cyanide (complexed)	250*
Lead	500
Mercury	1
Selenium	3
Thiocyanate	50
Organic Contaminants	
Coal Tar	50
Cyclohexane extractable	50
Phenol	5
Polycyclic Aromatic Hydrocarbons	50
Toluene extractable	50
Petroleum Hydrocarbons	50
Notes: * denotes 'it is not recommended that water pipes should be laid in sites where these substances are identified or suspected'.	

CONTROLLED WATERS

The GAC for controlled waters are presented in Table A3. In line with the Environment Agency's Remedial Targets Methodology dated December 2006, the GAC for controlled waters are termed 'target concentrations'.

The target concentration can be derived by several means with consideration to:

- Whether the substance is classified as List I or List II substance by the EU under the Groundwater Directive 80/68/EEC;
- Background concentrations in the aquifer; and
- Published guidance such as Environmental Quality Standards that are protective of ecology or The Water Supply (Water Quality) Regulations 2001 that are protective of drinking water.

A list of target concentrations considered suitable to assess risks to major aquifers and minor aquifers are presented in Table A3. Those for a major aquifer are taken from the UK Water Supply (Water Quality) Standards where possible owing to the possibility of a drinking water supply being within an influencing distance from the site or the possibility of one being installed. The target concentrations for a minor aquifer are generally taken as the freshwater Environmental Quality Standards where available owing to groundwater in minor aquifers commonly providing baseflow to surface watercourses.

Table A3: Target Concentrations for Controlled Waters

Determinant	Target Concentrations (mg/l)	
	Major Aquifer/Source Protection Zone	Minor Aquifer/Surface Watercourse
Metals		
Arsenic	0.01 ⁽¹⁾	0.05 ⁽⁷⁾
Cadmium	0.005 ⁽¹⁾	0.005 ⁽⁷⁾
Chromium (total)	0.05 ⁽¹⁾	0.005, 0.01, 0.02, 0.02, 0.05, 0.05 ⁽⁸⁾
Copper	2.0 ⁽¹⁾	0.001, 0.006, 0.01, 0.01, 0.01 0.028 ⁽⁸⁾
Lead	0.025 ⁽¹⁾	0.004, 0.01, 0.01, 0.02, 0.02, 0.02 ⁽⁸⁾
Mercury	0.001 ⁽¹⁾	0.001 ⁽⁷⁾
Selenium	0.01 ⁽¹⁾	0.01 ^(1,12)
Nickel	0.02 ⁽¹⁾	0.05, 0.1, 0.15, 0.15, 0.2, 0.2 ⁽⁸⁾
Zinc	5 ⁽²⁾	0.008, 0.05, 0.075, 0.075, 0.075, 0.125 ⁽⁸⁾
Chlorinated Solvents		
Trichloroethene	0.01 ⁽¹⁾	0.01 ⁽⁷⁾
Tetrachloroethene		0.01 ⁽⁷⁾
1,1,1-Trichloroethane	0.0001 ⁽³⁾	0.1 ⁽⁷⁾
1,1,2-Trichloroethane	0.0001 ⁽³⁾	0.4 ⁽⁷⁾
Carbon Tetrachloride	0.003 ⁽¹⁾	0.012 ⁽⁷⁾
1,2-Dichloroethane	0.003 ⁽¹⁾	0.01 ⁽⁷⁾
Vinyl Chloride	0.0005 ⁽¹⁾	0.0005 ^(1,12)
Trihalomethanes	0.1 ⁽⁴⁾	0.1 ^(4,12)
Chloroform (one of the trihalomethanes included above)	-	0.012 ⁽⁷⁾
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	0.0058 ^(9,13)	0.0058 ⁽⁹⁾
Acenaphthylene	0.0058 ^(9,13)	0.0058 ⁽⁹⁾

Anthracene	0.000012 ^(9,13)	0.000012 ⁽⁹⁾
Benzo(a)anthracene	0.000018 ^(9,13)	0.000018 ⁽⁹⁾
Benzo(b)fluoranthene	0.0001 ⁽¹⁾	0.000014 ⁽⁹⁾
Benzo(k)fluoranthene		0.000014 ⁽⁹⁾
Benzo(g,h,i)perylene		0.00002 ⁽⁹⁾
Indeno(1,2,3-cd)pyrene		No data ⁽⁹⁾
Chrysene	0.00001 ^(9,13)	0.00001 ⁽⁹⁾
Dibenzo(a,h)anthracene	0.00001 ^(9,13)	0.00001 ⁽⁹⁾
Fluoranthene	0.00001 ^(9,13)	0.00001 ⁽⁹⁾
Fluorene	0.0021 ^(9,13)	0.0021 ⁽⁹⁾
Phenanthrene	0.003 ^(9,13)	0.003 ⁽⁹⁾
Pyrene	0.00004 ^(9,13)	0.00004 ⁽⁹⁾
Benzo(a)pyrene	0.00001 ⁽¹⁾	0.000015 ⁽⁹⁾
Naphthalene	0.01 ^(9,13)	0.01 ⁽⁷⁾
Petroleum Hydrocarbons		
Total Petroleum Hydrocarbons	0.01 ⁽²⁾	0.01 ^(2,10)
Benzene	0.001 ⁽¹⁾	0.03 ⁽⁷⁾
Toluene	0.004 ⁽³⁾	0.05 ⁽⁷⁾
Ethylbenzene	0.02 ^(8,13)	0.02 ⁽⁸⁾
Xylene	0.003 ⁽³⁾	0.03 ⁽⁷⁾
Methyl t-Butyl ether	0.015 ⁽⁶⁾	0.015 ^(6,12)
Pesticides and Herbicides		
Aldrin	0.00003 ⁽¹⁾	0.00001 ⁽⁷⁾
Dieldrin	0.00003 ⁽¹⁾	0.00003 ^(1,12)
Heptachlor	0.00003 ⁽¹⁾	0.00003 ^(1,12)
Heptachlor epoxide	0.00003 ⁽¹⁾	0.00003 ^(1,12)
Other pesticides	0.0001 ⁽¹⁾	0.0001 ^(1,12)
Total pesticides	0.0005 ⁽¹⁾	0.0005 ^(1,12)
Endrin	0.000005 ^(7,13)	0.000005 ⁽⁷⁾
Total DDT	0.000025 ^(7,13)	0.000025 ⁽⁷⁾
Azinphos - methyl	0.00001 ^(7,13)	0.00001 ⁽⁷⁾
Cyfluthrin	0.000001 ^(7,13)	0.000001 ⁽⁷⁾
Demeton	0.0005 ^(7,13)	0.0005 ⁽⁷⁾
Dichlorvos	0.000001 ^(7,13)	0.000001 ⁽⁷⁾
Dimethoate	0.001 ^(7,13)	0.001 ⁽⁷⁾
Endosulphan	0.000003 ^(7,13)	0.000003 ⁽⁷⁾
Fenitrothion	0.000001 ^(7,13)	0.000001 ⁽⁷⁾
Flucifuron	0.001 ^(7,13)	0.001 ⁽⁷⁾
Malathion	0.00001 ^(7,13)	0.00001 ⁽⁷⁾
Mevinphos	0.00002 ^(7,13)	0.00002 ⁽⁷⁾
Omethoate	0.00001 ^(7,13)	0.00001 ⁽⁷⁾
PCSDs	0.00005 ^(7,13)	0.00005 ⁽⁷⁾
Permethrin	0.00001 ^(7,13)	0.00001 ⁽⁷⁾
Sulcofuron	0.025 ^(7,13)	0.025 ⁽⁷⁾
Triazaphos	0.000005 ^(7,13)	0.000005 ⁽⁷⁾
Atrazine & Simazine	0.002 ^(7,13)	0.002 ⁽⁷⁾
Bentazone	0.5 ^(7,13)	0.5 ⁽⁷⁾
Linuron	0.002 ^(7,13)	0.002 ⁽⁷⁾
Mecoprop	0.02 ^(7,13)	0.02 ⁽⁷⁾
Trifluralin	0.0001 ^(7,13)	0.0001 ⁽⁷⁾
Miscellaneous		
Cyanide	0.05 ⁽¹⁾	0.05 ^(1,12)
Phenol	0.0005 ⁽²⁾	0.03 ⁽⁷⁾
Sodium	200 ⁽¹⁾	170 ⁽⁷⁾
Chloride	250 ⁽¹⁾	250 ⁽⁷⁾
Ammonium (as NH ₄ ⁺)	0.5 ⁽¹⁾	0.5 ^(1,12)
Ammonia (NH ₃ as N)	0.015 ^(7,13)	0.015 ⁽⁷⁾
Sulphate	250 ⁽¹⁾	400 ⁽⁷⁾
Iron	0.20 ⁽¹⁾	1 ⁽⁷⁾
Manganese	0.05 ⁽¹⁾	0.05 ^(1,12)
Aluminium	0.2 ⁽¹⁾	0.2 ^(1,12)
Nitrate (as NO ₃)	50 ⁽¹⁾	50 ^(1,12)

Nitrite (as NO ₂)	0.5 ⁽¹⁾	0.5 ^(1,12)
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Notes

1. Statutory Instrument 2000 No 3184. The Water Supply (Water Quality) Regulations.
 2. Statutory Instrument 1989 No 1147. The Water Supply (Water Quality) Regulations, 1989.
 3. Environment Agency. Minimum Reporting Values listed in Appendix 7 of Hydrogeological Risk Assessments for Landfills and the Derivation of Groundwater Control and Trigger Levels. LFTGN01. Note target concentration for xylenes is 0.003mg/l each for o-xylene and m/p xylene.
 4. Statutory Instrument 1989 No 3184. The Water Supply (Water Quality) Regulations, 2000 – sum of chloroform, bromoform, dibromochloromethane and bromodichloromethane.
 5. Target concentration for Major Aquifer receptor taken as equal to target concentration for Minor Aquifer owing to absence of published guidance for PAH compounds other than those which are carcinogenic.
 6. Environment Agency MTBE Guidance.
 7. Freshwater Environmental Quality Standards.
 8. Freshwater Environmental Quality Standards for all fish life (including game) and dependent upon hardness range. Hardness ranges are: 0-50mg/l CaCO₃, 50-100 mg/l CaCO₃, 100-150 mg/l CaCO₃, 150-200 mg/l CaCO₃, 200-250 mg/l CaCO₃ and >250 mg/l CaCO₃. The target concentrations included in Table 3 are listed in order of increasing calcium carbonate concentrations.
 9. Polycyclic Aromatic Hydrocarbons (PAH): Priorities for Environmental Quality Standard Development, WRc Plc, R&D Technical Report P45. 2002. Where Predicted No-Effect Concentration is below the laboratory method detection limit (LMDL) for chrysene, dibenzo(ah)anthracene and fluoranthene, the target concentration has been set at the LMDL of 0.00001mg/l.
 10. Owing to hydrocarbons being List I substances, 0.01mg/l (DWS) should be used in the first instance against the total of the hydrocarbon bands. However, if the hydrocarbon concentrations measured in groundwater exceed this value, an alternative value of 0.05mg/l could be used providing it is justified based on the type of aquifer and distance to secondary receptors such as a stream. The value is taken as the lowest concentration in Statutory Instrument 1996 No. 3001 titled The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations, 1996.
 11. Value for ethylbenzene taken from R&D Technical Report P2-115/TR4 – Proposed Environmental Quality Standards for Ethylbenzene in Water.
 12. Where a published target concentration considered suitable for use with a minor aquifer could not be found for certain substances such as selenium, the target concentration used for the major aquifer has been adopted.
 13. Where a published target concentration considered suitable for use with a major aquifer could not be found for certain substances such as ethylbenzene, the target concentration used for the minor aquifer has been adopted.
- '-' A target concentration for chloroform for a major aquifer is absent since it is one of the trihalomethane compounds. See note 4 above.

APPENDIX J

Ground Gas Risk Assessment Spreadsheet

Generic NHBC Traffic Lights Ground Gas Risk Assessment

Job No.: 320469
Client: Bowsall
Site: Clitheroe

For low-rise residential developments with a clear ventilated sub-floor void ONLY

Traffic Light	Methane		Carbon Dioxide	
	TMV (%v/v)	GSV (l/hr)	TMV (%v/v)	GSV (l/hr)
Green				
Amber 1	1	0.16	5	0.78
Amber 2	5	0.63	10	1.56
Red	20	1.56	30	3.13

KEY:	
TMV	Typical Maximum Value
GSV	Gas Screening Value
	GSV can be calculated on a site-specific basis
	GSV within Green Traffic Light
	GSV within Amber 1 Traffic Light
	GSV within Amber 2 Traffic Light
	GSV within Red Traffic Light / TMV exceeded
	Oxygen concentration ≤10%v/v
	Total ground gas concentrations >100%v/v

From NHBC (2007, Edition No.: 04) "Guidance On Evaluation Of Development Proposals On Sites Where Methane And Carbon Dioxide Are Present", Boyle & Witherington

BH NO.	DATE	Water Level	CH4 I	CH4 SS	CO2 I	CO2 SS	O2 I	O2 SS	Flow l/hr	Baro mbar	BH Press mbar	I SUM	SS SUM	GSV	
			%v/v	%v/v	%v/v	%v/v	%v/v	%v/v				%v/v	%v/v	CH4	CO2
BH1	10/02/2011	1.534	<0.1	<0.1	0.9	0.8	20.2	19.5	0	1007		21.1	20.3	0.00	0.00
	18/02/2011	1.590	<0.1	<0.1	0.9	1.0	20.3	19.7	0	1010		21.2	20.7	0.00	0.00
	02/03/2011	1.598	<0.1	<0.1	0.7	0.9	20.8	20.1	0	1038		21.5	21.0	0.00	0.00
	17/03/2011	1.616	<0.1	<0.1	<0.1	<0.1	21.2	21.3	0	1011		21.2	21.3	0.00	0.00
												0.0	0.0	0.00	0.00
BH2	10/02/2011	0.346	<0.1	<0.1	<0.1	<0.1	19.6	19.4	-6.2	1007		19.6	19.4	0.00	0.00
	18/02/2011	0.753	<0.1	<0.1	<0.1	<0.1	20.7	20.7	-7.2	1010		20.7	20.7	0.00	0.00
	02/03/2011	0.752	<0.1	<0.1	<0.1	<0.1	20.7	20.8	0	1038		20.7	20.8	0.00	0.00
	17/03/2011	0.775	<0.1	<0.1	<0.1	<0.1	21.6	21.7	0	1011		21.6	21.7	0.00	0.00
												0.0	0.0	0.00	0.00
BH3	10/02/2011	-								1007		0.0	0.0	0.00	0.00
	18/02/2011	0.961	0.3	1.0	2.1	2.0	8.9	7.9	0.3	1010		11.3	10.9	0.00	0.01
	02/03/2011	1.100	2.3	2.4	2.1	2.2	12.7	0.3	2	1038		17.1	4.9	0.05	0.04
	17/03/2011	0.896	6.4	6.7	2.0	1.8	2.1	4.9	0	1011		10.5	13.4	0.00	0.00
												0.0	0.0	0.00	0.00

WORST-CASE VALUES PER BOREHOLE

		Maximum CH4		Maximum CO2		Minimum O2		Max Flow	Not Applicable	Maximum Total		Maximum GSVs	
	BH1	<0.1	<0.1	0.9	1.0	20.2	19.4	<0.1		21.1	20.4	0.00	0.00
	BH2	<0.1	<0.1	<0.1	<0.1	19.6	19.4	<0.1		19.6	19.4	0.00	0.00
	BH3	6.4	6.7	2.1	2.2	2.1	0.3	2.0		10.6	9.2	0.13	0.04

Appendix K

Geotechnical Certificates of Analysis

TESTING VERIFICATION CERTIFICATE



1774

The test results included in this report are certified as:-

ISSUE STATUS: **FINAL**

CHECKING STATUS: **CHECKED**

In accordance with Structural Soils Ltd Laboratory Quality Assurance Manual, Issue 6, January 2010 all results sheets and summaries of results issued by the laboratory are checked by an approved signatory. This check will also involve checking of at least 10% of calculations for each test type to ensure that data has been correctly entered into the computer and calculated. The integrity of the test data and results are ensured by control of the computer system employed by the laboratory as part of the Software Verification Program as detailed in the Laboratory Quality Assurance Manual.

This testing verification certificate covers all testing compiled on or before the following datetime: **28/02/2011 17:02:07**.

Testing reported after this date is not covered by this Verification Certificate.

Approved Signatory
Mark Athorne (Laboratory Quality Manager)



STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Contract:

Low Moor, Clitheroe

Job No:

780456

Sheet

1 of 5





STRUCTURAL SOILS LTD

TEST REPORT

Report No. 780456 R01

Date 28-February-2011 Contract Low Moor, Clitheroe

Client RSK Geoconsult Ltd
Address Spring Lodge
172 Chester Road
Helsby
Cheshire WA6 0AR

For the Attention of Steve Plater/Karl Hall

Samples submitted by client 14/02/2011
Testing Started 15/02/2011
Testing Completed 28/02/2011

Client Reference 320469
Client Order No.
Instruction Type Written

Ukas Accredited Tests Underatken

Moisture Content (oven drying method) BS1377:Part 2:1990,clause 3.2
Liquid Limit (definitive method) BS1377:Part 2:1990,clause 4.3
Plastic Limit BS1377:Part 2:1990,clause 5.3
Plasticity Index Derivation BS1377:Part 2:1990,clause 5.4

Non Ukas Accredited Tests Undertaken

Undrained shear strength triaxial compression without pore pressure measurement
(definitive method) 100mm diameter specimens BS1377:Part 7:1990,clause 8.4

Please Note: Remaining samples will be retained for a period of one month from today and will then be disposed of

Approved signatories: Mark Athorne (Laboratory Manager) ~~Sean Royle (Senior Technician)~~

Page 2 of 5

In accordance with clauses 3.2, 4.3, 4.4, 5.3, 5.4, 7.2, 8.2, 8.3 of BS1377:Part 2:1990

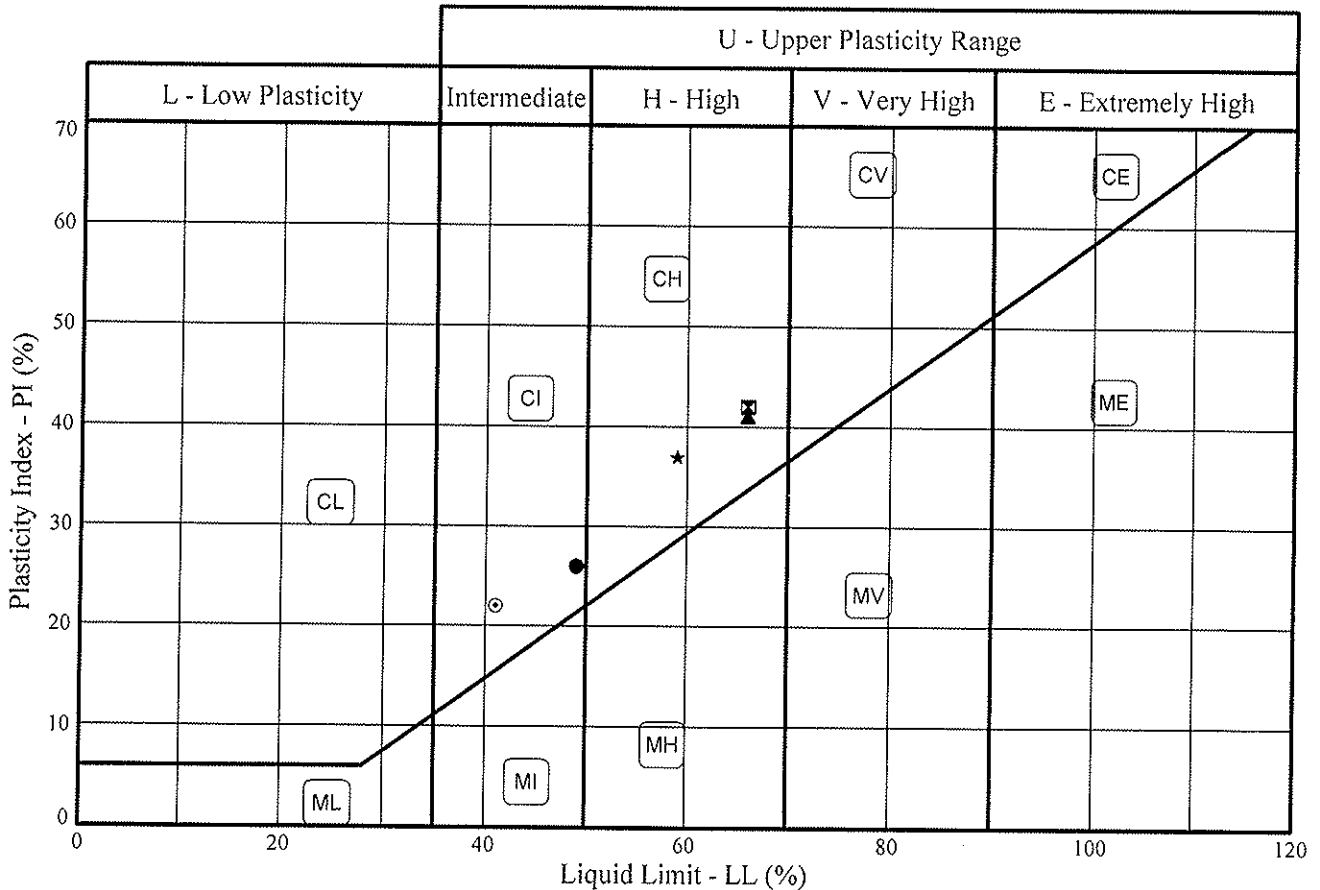
[illegible]

Approved Signatories: M. ATHORNE S. ROYLE M. FISHER T. KEMP

 STRUCTURAL SOILS The Potteries Pottery Street Castleford W. Yorkshire WF10 1NJ	Contract:		Low Moor, Clitheroe	Page	3 of S 	
	Compiled By	Date				Contract Ref:
	<i>M. Fisher</i>	28.02.11				780456

PLASTICITY CHART - PI Vs LL

In accordance with clause 42.3 of BS5930:1981
Testing in accordance with BS1377-2:1990



Sample Identification				BS Test Method #	Preparation Method +	MC %	LL %	PL %	PI %	<425um %
Exploratory Position ID	Sample	Depth (m)								
●	BH1	1B	0.50	3.2/4.3/5.3/5.4	4.2.4	21	49	23	26	73
☒	BH1	3D	1.20	3.2/4.3/5.3/5.4	4.2.4	19	66	24	42	83
▲	BH2	3U	1.20	3.2/4.3/5.3/5.4	4.2.3	27	66	25	41	100
★	BH2	4D	1.70	3.2/4.3/5.3/5.4	4.2.3	23	59	22	37	100
⊙	TP5	1B	1.20	3.2/4.3/5.3/5.4	4.2.4	29	41	19	22	60

Tested in accordance with the following clauses of BS1377-2:1990.

3.2 - Moisture Content
4.3 - Cone Penetrometer Method
4.4 - One Point Cone Penetrometer Method
4.6 - One Point Casagrande Method
5.3 - Plastic Limit Method
5.4 - Plasticity Index

+ Tested in accordance with the following clauses of BS1377-2:1990.

4.2.3 - Natural State
4.2.4 - Wet Sieved

Key: ★ = Non standard test, NP = Non plastic.

Approved Signatories: M. ATHORNE S. ROYLE M. FISHER T. KEMP



STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
<i>M. Fisher</i>		28/02/11
Contract		Contract Ref:
Low Moor, Clitheroe		780456
Page		4 of 5



BSI 377:Part 7:1990

Key : MS = Multi-stage, RM = Remoulded, B = Brittle, P = Plastic, C = Compound.

Approved Signatories: M. A. THORNE S. ROYLE M. FISHER T. KEMP

Compiled By

Date _____

Contract Ref:

The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

MAUREEN FISHER

28.02.11

Contract:

Low Moor, Clitheroe

Page

W. Yorkshire WF10 1NJ

505



APPENDIX L

Waste Acceptance Assessment

HASWASTE v4. Envirolab's Contaminated Land Soil Hazardous Waste Assessment Tool.
Envirolab, Sandpits Business Park, Mottram Road, Hyde, Cheshire SK14 3AR.



320469 - Clitheroe

TP/WS/BH
Depth (m)
Envirolab reference

Arsenic
CrVI or Chromium
Copper
Lead
Nickel
Zinc

Cadmium
Mercury
Selenium

Barium
Beryllium
Cobalt
Manganese
Molybdenum

Total USEPA 16 PAHs

Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(ghi)perylene
Benzo(k)fluoranthene
Chrysene
Dibenzo(ah)anthracene
Fluoranthene
Fluorene
Indeno(123cd)pyrene
Naphthalene
Phenanthrene
Pyrene

Benzo(j)fluoranthene

Benzene
Toluene
Ethylbenzene
Xylenes
Trimethylbenzenes

Chlorobenzene
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2,4-Trichlorobenzene
2-Chlorotoluene
4-Chlorotoluene

Trichloroethene (TCE)

Oil in Waste Carcinogenic H7

Total TPH

Petrol or (C6-C10)
Diesel or (C10-C25) or
(conservative C10-C35)
Lube Oil or (C25+) or
(conservative C21+)

8 IARC H7 Carcinogenic PAHs marker
test (applicable to LRQ only)

Kerosene

Kerosene

Creosote

Creosote

pH Corrosive H8 (Irritant H4)

pH (soil)

pH (leachate)

Alkali Reserve (gNaOH/100g)

H4 Alkali Reserve test

H8 Alkali Reserve test

Produces Toxic Gases H12

Total Sulphide

Free Cyanide

Thiocyanate

Elemental/Free Sulphur

PCBs Total

Phenols Total by HPLC

Phenol

Cresols

Xylenols

1-Naphthol

Resorcinol

2,3,5,6-Tetrachlorophenol

2,4,5-Trichlorophenol

2,4,6-Trichlorophenol

2,4-Dichlorophenol

4-Chloro-3-methylphenol

Pentachlorophenol

Bis(2-ethylhexyl)phthalate

Butylbenzylphthalate

Di-n-butylphthalate

Visual Fibre Screen or Asbestos

ID (enter Y or N)

BH1	BH1	BH2	BH3	BH3	TP-1	TP-2	TP-2	TP-3	TP-5	TP-7	TP-8	TP-9	
0.50	6.00	2.00	0.50	3.00	1.10	0.60	1.80	1.50	0.30	2.50	0.10	0.40	

mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
11			8				13		6	8		16	9
23			27				24		22	18		34	40
21			30				50		34	14		73	30
35			37				269		41	26		130	36
22			20				28		20	14		31	49
93			67				187		110	60		151	141

1.0			0.5				0.9		0.5	0.5		0.8	1.1
0.2			0.2				1.2		0.2	0.2		0.2	0.2
2			2				2		1	1		2	3

--	--	--	--	--	--	--	--	--	--	--	--	--	--

			0.03				0.06		0.02	0.01			0.04
			0.01				0.04		0.01	0.01			0.01
			0.03				0.12		0.04	0.02			0.02
			0.08				0.94		0.06	0.04			0.05
			0.08				0.92		0.08	0.01			0.05
			0.06				0.81		0.07	0.02			0.01
			0.12				1.05		0.11	0.02			0.04
			0.02				0.37		0.04	0.01			0.01
			0.16				1.29		0.14	0.07			0.09
			0.02				0.16		0.01	0.01			0.01
			0.17				1.16		0.15	0.06			0.07
			0.01				0.01		0.01	0.01			0.01
			0.03				0.73		0.02	0.01			0.01
			0.01				0.07		0.01	0.01			0.01
			0.03				0.34		0.08	0.06			0.09
			0.19				1.25		0.14	0.06			0.09

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0.01			0.01			0.01	0.01	0.01	0.01				
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0.1			0.1		56.4	103.0	2.4	6.4					
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0.01			0.01		0.01	0.01	0.01	0.01					
0.1			0.1		11.0	5.9	0.1	0.1					
0.1			0.1		45.4	97.5	1.2	4.9					

0.00	#DIV/0!	#DIV/0!	450.00	#DIV/0!	0.00	5.35	0.00	8.57	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
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8.1	8.3	8.5	8.3	8.5		8.5		7.9	7.7	8.6	7.2	7.4	
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8.1	8.3	8.5	8.3	8.5	0.0	8.5	0.0	7.9	7.7	8.6	7.2	7.4	0.0
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8.1	8.3	8.5	8.3	8.5	0.0	8.5	0.0	7.9	7.7	8.6	7.2	7.4	0.0
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