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Phase II Interpretative Ground Assessment

at

**Langholme Heights
Lower House Lane
Liverpool**

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3	July 2020	Updated with 2020 trial pitting exercise	CO	DB	AL
4	December 2021	Updated with cable percussion boreholes	ED	DE	WGB
Signatures					

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FOREWORD (Geotechnical and Environmental Assessment)

This report has been prepared for the sole internal use and reliance of the Client named on page 1. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Sutcliffe Investigation; such authorisation not to be unreasonably withheld. If any unauthorised third party comes into possession of this report, they rely on it at their risk and the authors owe them no duty of care and skill.

The report presents observations and factual data obtained during our site investigation, and provides an assessment of Geotechnical and environmental issues with respect to information provided by the Client regarding the proposed development. Further advice should be sought from Sutcliffe Investigation prior to significant revision of the development proposals. Primary aims of this exploratory phase of investigation were to identify salient geotechnical and environmental issues affecting the site to enable the client to obtain budget costs for the necessary site preparatory and remedial works.

The report should be read in its entirety, including all associated drawings and appendices. Sutcliffe Investigation cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context.

The findings and opinions conveyed in this report (including review of any third party reports) are based on information obtained from a variety of sources as detailed within this report, and which Sutcliffe Investigation believes are reliable. All reasonable care and skill has been applied in examining the information obtained. Nevertheless, Sutcliffe Investigation cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

The report represents the findings and opinions of experienced Geotechnical and environmental consultants. Sutcliffe Investigations does not provide legal advice and the advice of lawyers may also be required.

Intrusive investigation can only investigate shallow ground beneath a small proportion of the total site area. It is possible therefore that the intrusive investigation undertaken by Sutcliffe Investigation, whilst fully appropriate, may not have encountered all significant subsurface conditions. Any opinions expressed as to the possible configuration of strata between or below exploratory holes are for guidance only and no responsibility is accepted as to its accuracy.

It should be borne in mind that the timescale over which the investigation was undertaken might not allow the establishment of equilibrium groundwater levels. Particularly relevant in this context is that groundwater levels are susceptible to seasonal and other variations and may be higher during the wetter periods than those encountered during this commission.

Where the report refers to the potential presence of invasive weeds such as Japanese Knotweed, or the presence of asbestos containing materials, it should be noted that the observations are for information only and should be verified by a suitably qualified expert.

This report assumes that ground levels will not change significantly from those existing at present. If this is not to be the case, then some modification to this report may be required.

It should be noted that the banning of the co-disposal of hazardous and non-hazardous waste was introduced in 2011, as a result of the implementation within the UK of the Landfill Directive. This will considerably affect the current practices and procedures for the handling and disposal of wastes, in particular hazardous wastes. In addition, it will be a requirement for all wastes to be pre-treated and to comply with certain waste acceptance procedures prior to sending wastes to landfill. The full potential effects of these important changes are not known at this stage, but it is perceived that disposal costs will rise, particularly for hazardous wastes, and waste pre-treatment may, in some cases, become an 'additional' redevelopment cost with regard to the remediation of contaminated sites.

Should this report recommend that materials could be excavated and removed off site for landfill disposal, then it should be noted that the costs, timescales and implications of the pending changes to waste management legislation couldn't be predicted at this stage. Sutcliffe Investigation will not be responsible for changing practices, etc that may affect the viability of necessary remedial actions or of the implications of potential alternative treatment techniques.

Sutcliffe Investigation reserves the right to amend their conclusions and recommendations in the light of further information that may become available. General notes and limitations relevant to all Sutcliffe Investigations are described in the Foreword and should be read in conjunction with this report.

Executive Summary

INTRODUCTION	Sutcliffe Investigations was instructed by Cobalt Housing (<i>the “client”</i>) to undertake a Phase II ground assessment for the site at Langholme Heights located on Lower House Lane, Liverpool, L11 2SQ. The site is centred on Grid Reference (NGR) 338991, 395631 and is approximately 0.46ha in area. This report assesses the ground based geotechnical and environmental risks, constraints and liabilities associated with the proposed development of the site. This is required in support of the discharge of contaminated land planning conditions assigned to the site and to allow the design of economic foundation solutions.
SITE DESCRIPTION	The site is approximately square in shape, and can be accessed via East Lancashire Road to the north of the site and Stockmoor Road to the west of the site. The site was formally a 15 Storey, 44 meter high Tower block constructed in 1967. The site is currently relatively flat and covered with grass, with a small turning into the site off Stockmoor Road. The site is protected by a low level metal fence and a small length, low level brick wall on Stockmoor Road. The boundary to the adjoining properties is a 2.0m high brick wall. There are a number of lampposts around the perimeter of the site and a bus stop on East Lancashire Road with a number of Service boxes also noted around the site. The immediate surrounded area is predominantly residential developments with West Derby Cemetery noted on the eastern boundary beyond Lower House Lane.
DEVELOPMENT PROPOSAL	The proposed development for the site is apartments with associated car parking facilities and soft landscaping areas. The proposed development is presented as Drawing Ref.: LH-BTP-00-SP-DR-A-3682_113.C produced by BTP Architects (November 2020).
PRELIMINARY CONCEPTUAL MODEL	The earliest available historical map (1851) indicated that the site was under agricultural usage. By 1891 Brook House was noted on site (including glass houses) occupying at least 30% of the site, and remained on site until 1938 when the site became undeveloped land. New residential development was noted on site in 1954 noted as Stockmoor Bungalows (prefabricated), which remained on site until 1968-1972 when the development changed to a tower block of flats, noted as Langholme Heights, which remained on site until 2010 when the block was demolished and the site became undeveloped again. The potential for significant contamination to have arisen at the site as a result of the current and former usage on site is considered to be moderate. However, the possibility of contamination albeit likely to be localised cannot be discounted.
PREVIOUS WORKS	Sutcliffe's have completed a Phase I Desk Study, a synopsis of which is provided in Section 2 of this report, and also a Phase II Interim Datasheet Report was completed prior to this report. No other previous studies are known to have been undertaken to Sutcliffe's knowledge.
SITE INVESTIGATION	

	Site work was undertaken on the 25th November 2015 and consisted of: 4No. Window Sample Holes with a Dando Terrier 5No. Trial Pits with a JCB 3CX 4No. Gas monitoring installations 5No. Contamination samples from the Made Gound 5No. Speciated TPH Samples 5No. Leachate Samples 4No. Geotechnical Samples An additional trial pitting exercise was undertaken in June 2020 to try and locate the foundations / building footprint of the former on site building. This site investigation comprised of 4No. Trial Pits. Additional site investigation was undertaken on the 15th and 17th October 2021 and consisted of 3No. Cable Percussion Boreholes.
GROUND CONDITIONS	Made Ground: Made ground was encountered across the site in all exploratory holes and was noted to a maximum depth of 2.20m in TP3. The final depth of made ground was not provided in TP3 due to a concrete obstruction at 1.90m. The composition of made ground was generally noted to be grass and topsoil over over black / brown ashy / gravelly fine to coarse grained SAND with fine to coarse concrete and brick fragments and occasional root material (WS4, TP4, TP5). Also noted was brown, slightly sandy gravelly CLAY with fine to medium brick fragments and occasional whole bricks and rebar (TP5), sand was fine to medium and gravel was fine to medium and of mixed lithology. NOTE: A gas main was noted at 0.40m bgl and potential gas or water main at 0.60m bgl in TP1. A concrete slab was noted at 0.40m bgl and a land drain was noted at 1.20m bgl in TP2. A drain was noted at 1.10m bgl and a concrete obstruction was noted in at 1.90m bgl in TP3. A drain was noted at 1.00m bgl in TP5. Natural Ground: With the exception of TP3, noted above, natural ground was encountered across the site to a maximum depth of 5.45m in all window samples. The composition of natural deposits were noted to comprise of bands of sands and clays. Clay was noted to be predominantly stiff brown / grey sandy, gravelly CLAY with some grey veining and some loose and medium dense sand. Sand deposits were generally formed of loose to stiff brown fine to medium grained SAND. Clay deposits were generally found to be stiff brown sandy gravelly CLAY. SAND is fine to medium. GRAVEL is fine to medium subangular to subrounded and of mixed lithology. 2020 Trial Pitting Exercise: Investigations revealed no evidence of insitu foundations. Ground conditions comprised of Made Ground to a mximum depth of 1.50m bgl over red brown slightly friable / slightly silty / very sandy / slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular to subrounded and of mixed lithology. 2021 Cable Percussion Boreholes: Topsoil was underlain in each location by a black ashy gravelly SAND, with the gravel noted as fine to coarse concrete and brick. This Made Ground was noted from depths of 0.10m and 0.20m bgl, and was proven to depths between 0.6m and 1.1m bgl, achieving proven thicknesses of between 0.50m and 0.90m. Within BH103 a unique type of Made Ground was encountered from 0.60m to 1.60m bgl. The strata was recorded as a brown slightly sand slightly gravelly CLAY, with the gravel noted as fine to medium concrete and brick and rebar.

	Superficial strata were encountered underlying the Made Ground in every investigation location (interpreted as Glacial Till). The strata was noted to be variable in secondary constitutes throughout the boreholes but was generally encountered as a stiff to very stiff sandy gravelly CLAY, with the gravel noted as fine to medium mixed lithologies. The Glacial Till was encountered from between 1.00m and 1.60m bgl, proven to depths of between 17.39m and 18.19m blg, achieving proven thicknesses of between 15.79m and 17.19m. The stratum was not bottomed out during this site investigation. Bedrock strata was not encountered during this site investigation.
GROUNDWATER	Groundwater was recorded in WS1 at 3.00m and WS4 at 0.80m during the November 2015 site investigation works. During the October 2021 site investigation work, groundwater was recorded in all three cable percussion boreholes: • In BH101 at 14.00m and rose to 13.00m after 20mins (sealed at 12.50m). • In BH102 at 13.50m and rose to 12.80m after 20mins (sealed at 12.80m). • In BH103 at 11.80m and rose to 11.10m after 20mins (sealed at 12.10m).
ENVIRONMENTAL ASSESSMENT	Long Term Human Health (2015) Exceedances have not been recorded in any of the contaminants tested when compared to the relevant GACs. Asbestos identification was undertaken on all samples with no asbestos material being detected. The site does not pose a risk to human health, and remediation works are not required as part of the development. Sutcliffe would however propose to incorporate 300mm of clean imported tested material into all garden and soft landscaped areas to act as a growing medium. Controlled Waters Risk Assessment (2015) For controlled waters there are two assessment criteria, the Environmental Quality Standard (EQS) and the UK Drinking Water Standard (UKDWS). Screening values for Drinking Water Standards (UK DWS) have been used to assess leachability. UK DWS are relevant to potable receptors (Principal Aquifer, Bedrock). Environmental Quality Standards (EQS) screening values have been used to assess risks to surface water resources. When assessed against the EQS assessment values three samples for Copper (WS3, WS4 and TP2) were elevated. Arsenic was noted to be elevated in WS2 when compared against the UK DWS values. Exceedances of DWS and EQS screening criteria are not considered significant given the likely depth to groundwater, effects of natural attenuation, lack of nearby groundwater abstractions and the absence of any surface water courses that could be in continuity with ground water beneath the site.
ASBESTOS	Asbestos identification was undertaken on all samples with no asbestos material being detected.

GROUND GAS RISK ASSESSMENT	In accordance with CIRIA C665 the ground gas monitoring results currently indicate that the site has a Gas Screening Value (GSV) of 0.0042l/hr for methane and 0.0693l/hr for carbon dioxide. This results of this site classify the site as Green indicating a very low risk from ground gasses. Based on this no protective measures are required.
GEOTECHNICAL ASSESSMENT	Foundation Recommendations It is understood that the development will consist of apartments with associated car parking and soft landscaping areas. Due to the ground conditions encountered it would be Sutcliffe's recommendation that a piled foundation solution is adopted, with piles being taken to a suitable depth in natural strata for bearing. Final pile design will be undertaken by a specialist piling contractor. Limited groundwater ingress was recorded during site investigation works and during subsequent monitoring. Sub-surface concrete that is only in contact with Made Ground can be Design Sulphate Class DS-1, with an ACEC Classification of AC-1s. Ground Floor Construction Based upon the amount of Made Ground noted on site it is not recommended that a ground-bearing slab is utilised on site. Sutcliffe Investigations therefore propose a suspended P.C Unit ground floor be adopted.
RECOMMENDATIONS	The following actions are recommended: • Good hygiene practices should be employed during construction work, in addition, the findings of this investigation should be included within the contractors H&S file and an assessment of risks associated with short term human health completed. No consumption of food or smoking should occur without prior hand washing. If dust is encountered, dust masks should be worn and dust suppression employed. • Design a Phase III Remediation & Validation Proposal for submission to planning department. • Design a SMMP – Management of material on and off site.

NOTE: The executive summary is an overview of the key findings and conclusions of the report. There may be other information contained in the body of the main report which puts into context the information presented within the executive summary. No reliance should be placed on the executive summary.

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1 Introduction

1.1 Terms of Reference

Sutcliffe Investigations were instructed by Cobalt Housing (*the “client”*) to undertake a Phase II ground assessment for the site at Langholme Heights located on Lower House Lane, Liverpool, L11 2SQ.

NOTE: Sutcliffe’s were instructed to conduct a geotechnical exercise in order to find the previous foundation building footprints, which was completed during the 2020 site investigation.

The location of the site is presented as *Figure 1*. The site is centred on Grid Reference (NGR) 338991, 395631 and is approximately 0.46ha in area. Site layout is presented as an aerial photograph in *Figure 2*.

This report assesses the ground based geotechnical and environmental risks, constraints and liabilities associated with the proposed development of the site. This is required in support of the discharge of contaminated land planning conditions assigned to the site and to allow the design of economic foundation solutions.

1.2 Legislative Context

The presence of contaminants which may pose a risk to human health or the environment is a material planning consideration. For planning it should be considered whether the site is suitable for its new use, and the responsibility for securing a safe development (including cumulative effects of pollution on health, and the potential sensitivity of the proposed development to adverse effects from pollution,) rests with the developer and/or landowner. Planning is concerned with the site’s proposed use not its current use, where the amount of contamination is expected to be low relative to the level of risk. This is the opposite to Part 2A which considers high levels (significant harm) and the current use of the site.

Section 57 of the Environment Act 1995, adds Part 2A (ss.78A-18YC) to the Environmental Protection Act 1990 and contains the legislative framework for identifying and dealing with contaminated land. Where development is undertaken on land which may be affected by contamination, the National Planning Policy Framework, paragraphs 120 to 122 considers pollution and remediation. This links the contaminated land regime within the development process.

For there to be an environmental liability associated with the site there must be a perceived source (a contaminant), a receptor (humans, living organisms or property) and a pathway between them. The potential presence of all of these aspects would result in a complete contaminant linkage.

In accordance with environmental legislation and the associated guidelines, assuming the site is to be redeveloped as housing, it should be noted that any redevelopment of the site could actually create new pathways that could increase the liabilities associated with the site. In addition, the basis of the intrusive ground assessment is to refine the preliminary conceptual model.

1.3 Site Location and Setting

Langholme Heights is located on Lower House Lane, Liverpool, L11 2SQ, at National Grid Reference (NGR) 338991, 395631. Location plan shown as Figure 1.

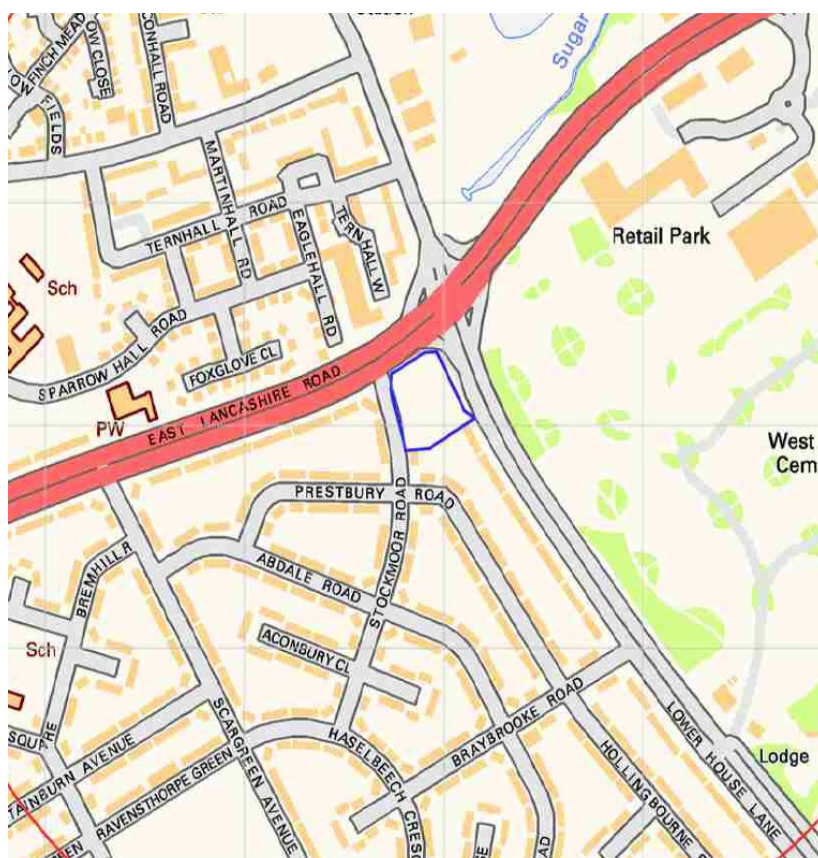


Figure 1: General Location of Site

1.4 Proposed Development

The proposed development for the site is apartments with associated car parking facilities and soft landscaping areas. The proposed development is presented as Drawing Ref.: LH-BTP-00-SP-DR-A-3682_113.C produced by BTP Architects (November 2020).

1.5 Site Description and Layout

The site is approximately square in shape, and can be accessed via East Lancashire Road to the north of the site and Stockmoor Road to the west of the site.

The site was formally a 15 Storey, 44 meter high Tower block constructed in 1967.

The site is currently relatively flat and covered with grass, with a small turning into the site off Stockmoor Road. The site is protected by a low level metal fence and a small length, low level brick wall on Stockmoor Road. The boundary to the adjoining properties is a 2.0m high brick wall. There are a number of lampposts around the perimeter of the site and a bus stop on East Lancashire Road with a number of Service boxes also noted around the site.

The immediate surrounded area is predominantly residential developments with West Derby Cemetery noted on the eastern boundary beyond Lower House Lane.



Figure 2: Aerial Photograph of the Site (land currently undeveloped and buildings demolished)

1.6 Previous Studies

Sutcliffe's have completed a Phase I Desk Study, a synopsis of which is provided in Section 2 of this report and also a Phase II Interim Datasheet Report was completed prior to this report.

No other previous studies are known to have been undertaken to Sutcliffe's knowledge

1.7 Objectives & Scope of Assessment

The aim of the intrusive ground investigation is to identify potential environmental liabilities and constraints, associated with the development of the site area in support of the following:

- A planning application and the discharge of contaminated land conditions where reasonably practicable that may have been assigned to the site and to include the design of a remediation scheme, if required.
- To assess the likelihood of reuse of materials that are site won or disposal options for surplus material.
- The preliminary design of detailed and economic foundations options inclusive of all information and specifications relating to foundation types, the location of underlying rock, (if encountered), preparation of ground, concrete grades, reuse of materials for both the proposed building, and the existing foundations.

2 Preliminary Conceptual Risk Assessment

2.1 Ground Model

The earliest available historical map (1851) indicated that the site was under agricultural usage. By 1891 Brook House was noted on site (including glass houses) occupying at least 30% of the site, and remained on site until 1938 when the site became undeveloped land. New residential development was noted on site in 1954 noted as Stockmoor Bungalows (prefabricated), which remained on site until 1968-1972 when the development changed to a tower block of flats, noted as Langholme Heights, which remained on site until 2010 when the block was demolished and the site became undeveloped again.

The potential for significant contamination to have arisen at the site as a result of the current and former usage on site is considered to be moderate. However, the possibility of contamination albeit likely to be localised cannot be discounted.

2.2 Potential Contaminant Linkages

2.2.1 Sources

The likely contaminants from made ground associated with former site usage, infilling activity which may be present on site could include: heavy metals such as cadmium, chromium, copper, lead, nickel and zinc, asbestos, hydrocarbons and organic compounds such as Polycyclic Aromatic Hydrocarbons (PAHs). Furthermore, ground gases such as methane and carbon dioxide may be generated from areas of made ground material.

No significant off site sources have been identified that represent a significant risk to the site.

The likely contaminants from previous land uses are shown below in *Table 2.1*.

Table 2.1: Potential Source (s) of contamination

Reference	Potential Sources (Onsite)	Potential Contaminants
S1	Demolished housing, potential oil fired heating and demolished tower block	All metals, fuel, hydrocarbons and oils, asbestos and localised ground gas.

2.2.2 Receptors

The most sensitive receptors identified using the conceptual site model are considered to be site and adjacent site users, construction and maintenance workers, controlled waters (aquifer), infrastructure and buried services. These are most likely to be affected by previous site users, made ground and any associated contaminants and gas generated from made ground, if present on site.

Human receptors would comprise construction workers, future site users and adjacent site users. It is likely that the exposure to contamination by construction workers will be limited due to the short exposure to the potential contamination and the use of PPE. If ground gases are produced this could be a potential risk to the future site users and properties and workers in confined spaces / trenches etc.

Due to the potential for contaminants to be present on site there is the potential for contaminants to leach and migrate to the underlying Principal Aquifer. Drift material is noted to be present under the site and is classified as Unproductive Strata, this will act as an aquiclude, reducing the risk to the underlying aquifer.

Table 2.2 below details the potential receptors.

Table 2.2: Receptors

Ref	Receptor	Description
R1	Current & future site users	Site users; personnel, general workers and maintenance workers,
R2	Construction Workers	Contractors working on the development of the site. Construction workers, maintenance workers or other personnel who may be directly exposed to contaminated materials in the course of their activities).
R3	Controlled Waters	Principal Aquifer and Unproductive Strata and on site drainage
R4	Adjacent Site Users	Adjacent site users. Third-party land (<i>i.e.</i> the possibility of contamination migrating off-site onto third party land <i>via</i> contaminated groundwater, surface water run-off).
R5	Infrastructure / Buried services	Proposed buildings and buried services

2.2.3 Pathways creating contaminant linkages

Table 2.3: Pathways

Ref	Pathway	Description
P1	Direct contact with potential contaminants.	Dermal absorption, ingestion and inhalation of contaminants via direct contact.
P2	Ingestion of potential contaminants.	Construction workers may come into contact during the site works, however this will be for a short time and therefore limited exposure will occur. PPE can be used and worn as a precaution to reduce the risk.
P3	Inhalation of potential contaminants.	
P4	Leaching and migration of contaminants.	Leaching of possible contaminants could migrate into the underlying Principal Aquifer via shallow groundwater. On site drainage is also at risk from shallow contamination, if present.
P5	Vertical and lateral migration of ground gases / vapours.	There is the potential for contaminants to be present on the site, which could generate ground gas & vapours on site.

2.3 Risk Evaluation

Each potential contaminant linkage is identified in *Table 2.4* below. An evaluation of the risk that each contaminant linkage poses to the project (as identified in the section 2) has been undertaken, in general accordance with CIRIA guidance document C552, 2001.

The evaluation and the resultant actions identified are based on the available information presented within this report. A visual representation of the Preliminary CSM is presented as Figure 3.

Table 2.4: Preliminary Risk Evaluation of Potential Contaminant Linkages

1. Hazard Identification		2. Hazard Assessment				3. Risk Estimation		4. Risk Evaluation	5. Managing the Risk
Contaminant Source		Pathway		Receptor		Consequence of risk being realised	Probability of risk being realised	Classification	Action required
S1	Potentially contaminated soil on Site	P1	Dermal contact	R1/2	Site users	Medium	Low	Moderate / Low	It is possible that harm could arise to a designated receptor from an identified hazard. Investigation is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.
		P2	Ingestion of soil / soil dust	R1/2	Site users	Medium	Low	Moderate / Low	
		P3	Inhalation of vapours / soil gas	R1/2	Site users	Severe	Unlikely	Moderate / Low	
		P4	Leaching and migration of contaminants	R3/5	Principal aquifer	Medium	Low	Moderate / Low	
		P5	Lateral migration of soil gas / vapours	R1	Site users	Severe	Unlikely	Moderate / Low	
				R4	Property	Severe	Unlikely	Moderate / Low	

3 Ground Investigation

3.1 Design Rationale

The aim and design of the ground assessment is to satisfy planning conditions assigned to the site by reference to the National Planning Policy Framework. This will identify elevated concentrations of determinands with the aim of assessing long term human health risks to site users and groundwater resources. In addition, the works have been designed to allow the design of economic foundation solutions for the proposed new builds.

3.2 Fieldwork

Initial field works were undertaken 25th November 2015 by Paul Blackledge Drilling and further site work was undertaken on 15th & 17th October 2021 by VC Drilling, both are specialist ground investigation contractors as well as Sutcliffe. The investigations were carried out in general accordance with the following standards:

- *BS EN 1997-2:2007 Eurocode 7: Geotechnical design. Ground investigation and testing;*
- *BS10175:2011 Code of Practice for the Investigation of Potentially Contaminated Sites;*
- *Secondary Model Procedure for the Development of Appropriate Soil Sampling Strategies for Land Contamination, 2001 (Environment Agency).*
- *BS 5930:2015 Code of practice for site investigations; and,*
- *BS EN ISO 22475-1:2006 Geotechnical investigation and testing. Sampling methods and groundwater measurements. Technical principles for execution.*

Window sample and trial pit logs collated as part of the 2015 ground investigation completed by Sutcliffe are presented in *Appendix C*. Following on from these works an additional trial pitting exercise was undertaken in June 2020 in order to try and locate the previous foundation building footprint. These trial pit logs are also present in *Appendix C*. Cable percussion logs collated as part of the 2021 ground investigation completed by Sutcliffe are also presented in *Appendix C*.

A summary of exploratory hole detailing rationale is shown in *Table 3.1* below, this also includes details of the trial pits carried out in June 2020 and cable percussion boreholes carried out in October 2021.

Table 3.1: Summary of Site Activities

Exploratory Hole ID	Location Rationale	Method	Completed Depth (mbgl)	Installation Details	Sampling details
WS1 (2015)	General Site Coverage (GG, GW, HH, GEO)	Window Sampler	5.45	Standpipe installed to 3.00m bgl	SPTs
WS2 (2015)	General Site Coverage (GG, HH, GEO)	Window Sampler	5.45	Standpipe installed to 3.00m bgl	SPTs Vanes
WS3 (2015)	General Site Coverage (GG, HH, GEO)	Window Sampler	5.45	Standpipe installed to 3.00m bgl	SPTs
WS4 (2015)	General Site Coverage (GG, GW, HH, GEO)	Window Sampler	5.45	Standpipe installed to 3.00m bgl	SPTs
TP1 (2015)	General Site Coverage	JCB	2.00	No installation	-
TP2 (2015)	General Site Coverage (HH)	JCB	2.00	No installation	-
TP3 (2015)	General Site Coverage	JCB	2.20	No installation	-
TP4 (2015)	General Site Coverage	JCB	2.00	No installation	-
TP5 (2015)	General Site Coverage	JCB	1.80	No installation	-
TP101 (2020)	Locate Former Buiding Footprint / Foundations	JCB	1.70	No installation	-
TP102 (2020)	Locate Former Buiding Footprint / Foundations	JCB	1.30	No installation	-
TP103 (2020)	Locate Former Buiding Footprint / Foundations	JCB	1.50	No installation	-
TP104 (2020)	Locate Former Buiding Footprint / Foundations	JCB	1.60	No installation	-
BH101 (2021)	General Site Coverage	Cable Percussion	18.19	No installation	SPTs and U100 samples
BH102 (2021)	General Site Coverage	Cable Percussion	18.13	No installation	SPTs and U100 samples
BH103 (2021)	General Site Coverage	Cable Percussion	17.39	No installation	SPTs, U100 & Bulk samples

GG – Ground Gas / GW – Groundwater / HH – Human Health / GEO – Geotechnical

3.3 Chemical Laboratory Testing

Selected soil samples from the 2015 investigation were collected at various depths and horizons and submitted for chemical analysis, details of which are presented in *Table 3.2*

Table 3.2: Summary of Soils Analysis (Total & Leachate Concentrations)

Suite Reference	Analysis Suite
Soils Suite – total	<i>Metals suite, speciated (16) polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons according to the Total Petroleum Hydrocarbon Working Group (TPHCWG), asbestos screen, total cyanide, phenols and soil organic matter.</i>
Leachate – total	<i>Metals suite, speciated (16) PAHs.</i>

* Please note chemical sampling was not undertaken as part of the June 2020 investigation

All samples were stored in airtight containers appropriately labelled, and transported in cool boxes with icepacks maintained at 4°C, under completed chain of custody documentation to Exova laboratories.

All samples were analysed by MCERTS accredited soil analysis laboratory Exova under UKAS accredited methods. All samples have been taken in accordance with current British Standards.

Exova are appropriately accredited for the works required and are an approved supplier under the Sutcliffe's Quality Management System.

Analytical test certificates are presented in *Appendix D*.

TPH Speciated aromatic and aliphatic bands with BTEX analysis have been carried out in line with the TPHCWG. The toxicity and migration risk associated with a TPH is dependent on the specific aliphatic aromatic carbon banding. Of particular concern are the low molecular weight compounds, which are highly mobile and show a greater level of toxicity than the higher molecular weight compounds. Therefore a low TPH consisting of low molecular weight aliphatic and aromatic carbon banding compounds may present more of a risk than a high TPH consisting of heavy weight aliphatic and aromatic carbon banding compounds.

Based on the TPHCWG the aromatic band C5 – C7 is considered to consist only of Benzene and the aromatic band C7 – C8 of Toluene. Therefore the more specific BTEX analysis has been used for risk assessment rather than the aromatic bands.

4 Ground Model

4.1 November 2015 Ground Investigation

Made Ground: Made ground was encountered across the site in all exploratory holes and was noted to a maximum depth of 2.20m in TP3. The final depth of made ground was not provided in TP3 due to a concrete obstruction at 1.90m.

The composition of made ground was generally noted to be grass and topsoil over over black / brown ashy / gravelly fine to coarse grained SAND with fine to coarse concrete and brick fragments and occasional root material (WS4, TP4, TP5). Also noted was brown, slightly sandy gravelly CLAY with fine to medium brick fragments and occasional whole bricks and rebar (TP5), sand was fine to medium and gravel was fine to medium and of mixed lithology.

NOTE: A gas main was noted at 0.40m bgl and potential gas or water main at 0.60m bgl in TP1.

A concrete slab was noted at 0.40m bgl and a land drain was noted at 1.20m bgl in TP2.

A drain was noted at 1.10m bgl and a concrete obstruction was noted in at 1.90m bgl in TP3.

A drain was noted at 1.00m bgl in TP5.

Natural Ground: With the exception of TP3, noted above, natural ground was encountered across the site to a maximum depth of 5.45m in all window samples.

The composition of natural deposits were noted to comprise of bands of sands and clays. Clay was noted to be predominantly stiff brown / grey sandy, gravelly CLAY with some grey veining and some loose and medium dense sand.

Sand deposits were generally formed of loose to stiff brown fine to medium grained SAND.

Clay deposits were generally found to be stiff brown sandy gravelly CLAY. SAND is fine to medium. GRAVEL is fine to medium subangular to subrounded and of mixed lithology.

A summary of the strata depths and thicknesses is detailed in *Table 4.1*.

Table 4.1: Ground Conditions Encountered during 2015 Investigation

Strata	Depths encountered (mbgl)		Thickness (m)		
	Min	Max	Min	Max	Average
Made Ground	0.00	2.20**	0.50	2.20	1.01**
Natural Ground – Sand and Clays	2.20	5.45	0.50	4.95	2.84

** Final Depth of Strata not proven, average thickness on identified ground.

The characteristic values for the made & natural ground are shown below in *Table 4.2*.

Table 4.2: Material Properties

Property	No. of Tests	Range	Average
SAND SPT N Values	3	7-16	11.7
CLAY SPT N Values	17	9-23	17.7

4.2 Ground Model (2020)

Following the initial site investigation in November 2015, an additional trial pitting exercise was undertaken in June 2020, the purpose of this was to try and locate former building footprint.

No evidence of insitu foundations were discovered.

The ground conditions identified during this trial pitting exercise comprised of Made Ground to a maximum depth of 1.50m bgl over red brown slightly friable / slightly silty / very sandy / slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular to subrounded and of mixed lithology.

4.3 October 2021 Ground Investigation

Made Ground: Made Ground was encountered within all three of the investigation locations.

A Made Ground topsoil was encountered within each location from ground level and proven to depths of between 0.10m and 0.20m bgl. The Topsoil was noted as Grass over brown fine to medium-grained SAND, with root material.

The Topsoil was underlain in each location by a black ashy gravelly SAND, with the gravel noted as fine to coarse concrete and brick. This Made Ground was noted from depths of 0.10m and 0.20m bgl, and was proven to depths between 0.6m and 1.1m bgl, achieving proven thicknesses of between 0.50m and 0.90m.

Within BH103 a unique type of Made Ground was encountered from 0.60m to 1.60m bgl. The strata was recorded as a brown slightly sand slightly gravelly CLAY, with the gravel noted as fine to medium concrete and brick and rebar.

Natural Ground: Superficial strata were encountered underlying the Made Ground in every investigation location (interpreted as Glacial Till). The strata was noted to be variable in secondary constituents throughout the boreholes but was generally

encountered as a stiff to very stiff sandy gravelly CLAY, with the gravel noted as fine to medium mixed lithologies.

The Glacial Till was encountered from between 1.00m and 1.60m bgl, proven to depths of between 17.39m and 18.19m blg, achieving proven thicknesses of between 15.79m and 17.19m. The stratum was not bottomed out during this site investigation.

Bedrock strata was not encountered during this site investigation.

Table 4.3: Ground Conditions encountered during October 2021 Investigation

Strata	Depths encountered (mbgl)		Thickness (m)		
	Min	Max	Min	Max	Average
Made Ground	0.10	1.60	0.90	1.50	1.10
Stiff, greyish brown, slightly sandy , slightly gravelly CLAY. Sand is fine to medium. Gravel is fine to medium, subangular of mixed lithologies.	1.00	9.95	3.00	8.35	5.42
Very stiff, brown, occasionally laminated, sandy, gravelly CLAY. Sand is fine to medium. Gravel is fine to medium, subangular to subrounded of mixed lithologies.	4.10	18.19**	7.44	14.03	11.25**

** Final Depth of Strata not proven, average thickness on identified ground.

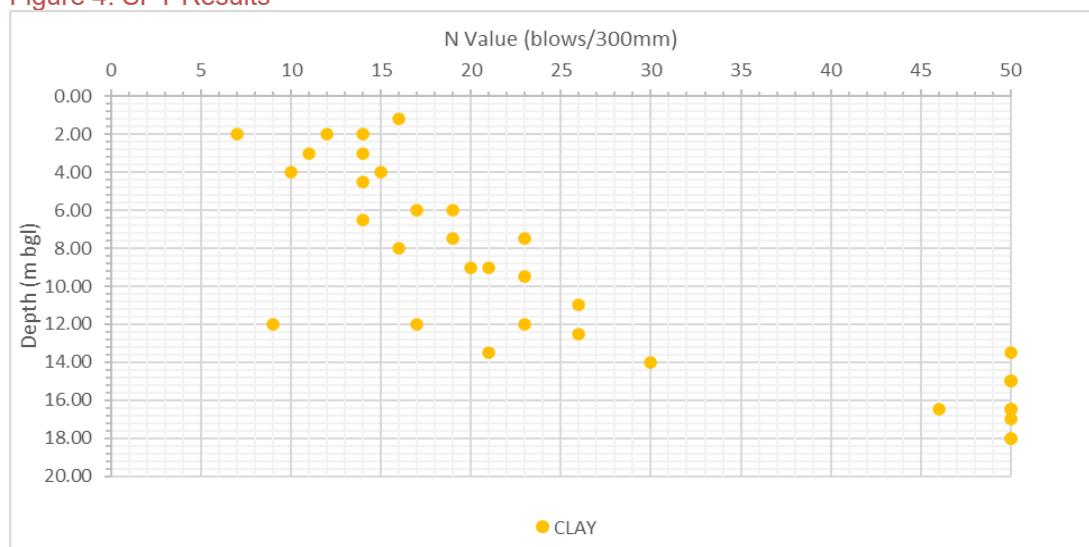
The October 2021 site investigation works have consisted of 3No. Cable percussion boreholes. In-situ site testing has been carried out using standard penetration testing (SPT).

SPTs were undertaken within the Glacial Till, as shown in *Table 4.4* and *Figure 4* below.

Table 4.4: Material Properties

Property	No. of Tests	Range	Average
CLAY SPT N Values	35	7->50	27

Figure 4: SPT Results



4.4 Field Evidence of Contaminated Soils

Field evidence of contamination was identified across site in the form of made ground encountered to depths of between 0.00-2.20m bgl.

4.5 Groundwater

Groundwater was recorded in WS1 at 3.00m and WS4 at 0.80m during site investigation works. During the October 2021 site investigation, groundwater was recorded in all three cable persussion boreholes:

- In BH101 at 14.00m and rose to 13.00m after 20mins (sealed at 12.50m).
- In BH102 at 13.50m and rose to 12.80m after 20mins (sealed at 12.80m).
- In BH103 at 11.80m and rose to 11.10m after 20mins (sealed at 12.10m)

In accordance with the agreed scope of works monitoring of groundwater installations completed by Sutcliffe's (2015) will be undertaken using an electronic ATEX Dipmeter on six occasions, results of which are presented in *Table 4.4*.

Table 4.4: Groundwater Monitoring Data

Location	Water Level (m bgl)					
	08.12.15	21.12.15	06.01.16	21.01.16	12.02.16	16.02.16
WS1	1.07	1.02	0.31	1.02	0.99	0.92
WS2	0.73	0.71	0.79	1.12	1.12	1.16
WS3	-	-	-	-	-	-
WS4	FULL	0.23	0.31	FULL	FULL	FULL

A full set of groundwater monitoring data is presented as *Appendix E*.

4.6 Stability

No evidence of instability was noted in the exploratory holes that were undertaken on site, however due to the amount of made ground noted on site shoring would likely be required if any groundworks are to be left open during site works.

Drainage

It is recommended that the client / developer contact United Utilities with respect to capacity in existing foul and surface water sewers in the vicinity of the development area.

Please note the testing suite carried out for this site is for human health purposes and may not cover the suite of contaminants required by United Utilities for pipe selection, therefore further testing may be required.

Services

It is recommended that the client / developer contact the relevant service provided to ascertain the requirements for power reinforcement and / or relocation / diversion of existing services.

5 Geotechnical Laboratory Testing and Assessment

5.1 Geotechnical Testing and Issues (2015)

Plasticity Index

A total of four samples were tested to determine the plasticity index of the underlying strata spread across WS1, WS2, WS3 & WS4 and taken from depths of between 1.00-3.00m bgl. The plasticity results and the modified plasticity index are outlined in *Table 4.5* below.

Table 5.1: Plasticity Test Results

Borehole Number	Depth From (m)	Depth To (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Passing 0.425m m (%)	Modified Plasticity Index (%)	Soil Classification
WS1	1.70	1.90	30	13	17.00	90	15.3	CL
WS2	1.00	2.00	-	-	-	91	-	NP
WS3	1.60	1.80	31	13	18.00	98	17.64	CL
WS4	2.50	3.00	31	13	18.00	95	17.1	CL

The results indicate that the underlying CLAY is low plasticity. Plasticity test results are included in *Appendix F*.

Soluble Sulphate and pH

It is envisaged foundations will extend through the Made Ground and into the natural strata and samples taken from the Made Ground have been submitted for pH and water-soluble sulphate (2:1 soil/water extract) analysis.

The highest water-soluble sulphate concentration and the lowest pH value for the Made Ground is shown in *Table 4.6*.

Table 5.2: Soluble sulphate and pH classification

Soil Type	Lowest pH Values	Highest Soluble Sulphate Concentration (g/l)
Made Ground	8.02	0.09

Therefore, in accordance with Table C2 of BRE: Special Digest 1 2005, sub-surface concrete that is in contact with Made Ground should be Design Sulphate Class **DS-1**, with the ACEC classification of **AC-1s**.

A complete set of geotechnical laboratory certificates are presented in *Appendix F*.

5.2 Geotechnical Testing and Issues (2021)

General

In total 4No. samples were recovered from site for the purpose of geotechnical laboratory testing. A breakdown of the testing scheduled is set out in *Table 5.3* below.

Table 5.3: Geotechnical Testing

Ref. No.	Depth (mbgl)	Moisture Content	Plasticity Index	Triaxial	Hand Shear Vane
BH101	5.00-5.45	✓	✓	✓	
BH102	5.00-5.45	✓	✓		✓
BH103	5.00-5.45	✓	✓	✓	
BH103	15.00-15.45	✓	✓		✓

Plasticity Index

A total of 4No. samples were tested to determine the plasticity index of the underlying CLAY strata. The plasticity results and the modified plasticity index are outlined in *Table 5.4* below.

Table 5.4: Plasticity Test Results

Ref. No.	Depth (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Passing 0.425mm (%)	Modified Plasticity Index (%)	Soil Classification
BH101	5.00-5.45	33	17	16	91	14.56	CL
BH102	5.00-5.45	34	17	17	94	15.98	CL
BH103	5.00-5.45	32	16	16	86	13.76	CL
BH103	15.00-15.45	36	17	19	90	17.1	CL

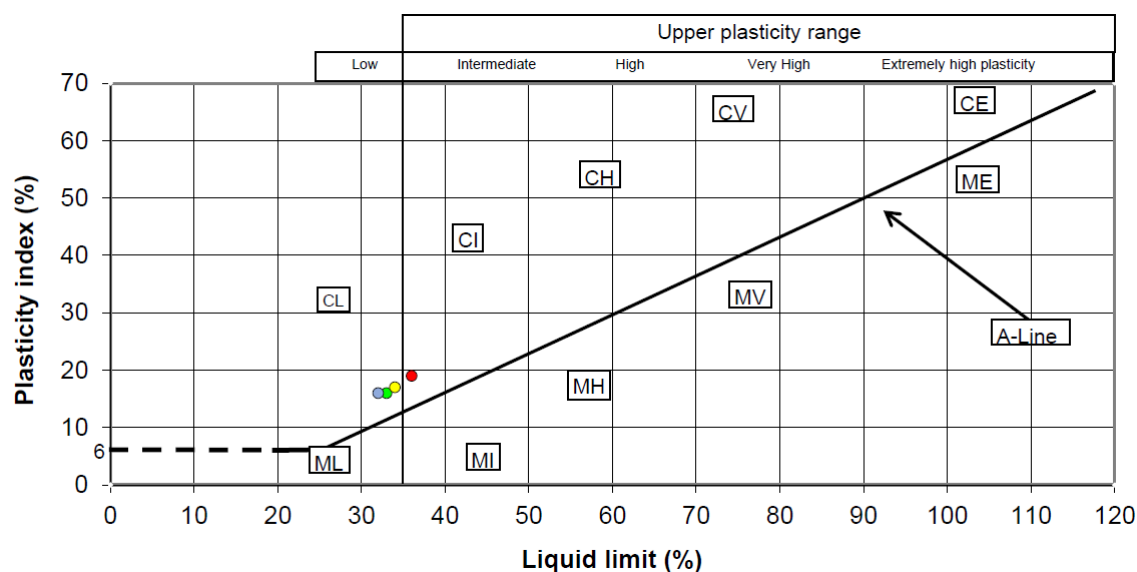


Figure 5: Plasticity Test Results

The results indicate that the underlying CLAY is low plasticity. Plasticity test results are included in *Appendix F*.

Shear Strength - Triaxial Testing

Triaxial testing was scheduled on 3No. samples recovered from site. The result of this testing is outlined below in *Table 5.5*.

Table 5.5: Triaxial Test Results

Ref. No.	Depth (m bgl)	Shear Strength (kPa)
BH101	5.00-5.45	78
BH103	5.00-5.45	54

Shear Strength – Hand Shear Vane (HSV) Testing

2No. HSV Tests were carried out on samples recovered from site. The results are outlined below in *Table 5.6*.

Table 5.6: Laboratory HSV Test Results

Ref. No.	Depth (m bgl)	Shear Strength (kPa)
BH102	5.00-5.45	90
BH103	15.00-15.45	110

Shear Strength Testing Summary

The results of this testing indicate that the shear strength of the clay classifies as firm to stiff, the strength of the clay increases with depth at BH103.

5.3 Foundation Recommendations

General

It is understood that the development will consist of apartments with associated car parking and soft landscaping areas.

Due to the ground conditions encountered it would be Sutcliffe's recommendation that a piled foundation solution is adopted, with piles being taken to a suitable depth in natural strata for bearing. Final pile design will be undertaken by a specialist piling contractor.

Limited groundwater ingress was recorded during site investigation works and during subsequent monitoring.

Sub-surface concrete that is only in contact with Made Ground can be Design Sulphate Class DS-1, with an ACEC Classification of AC-1s.

Ground Floor Construction

Based upon the amount of Made Ground noted on site it is not recommended that a ground-bearing slab is utilised on site. Sutcliffe Investigations therefore propose a suspended P.C Unit ground floor be adopted.

Designated Concrete Mixes

The following designated mix in accordance with BRE Special Digest SD1 and BS 8500: Part1: 2015 will be suitable for use on this site.

Table 4.7: Designated Concrete Mixes

Application	DS-1 Conditions (Made Ground and Natural) ACEC Class AC-1s
Unreinforced strip / trench fill footings	GEN1
Reinforced strip / trench fill footing (mesh reinforcement)	RC30
Reinforced strip / trench fill footings (rebar etc)	RC30
Unreinforced concrete floor slabs	GEN2
In situ reinforced concrete floor slabs	RC30

*Note: Although RC 30 is in line with BS8500, Sutcliffe Investigation recommend the use of RC35 for concrete used in structurally sensitive works, to provide greater certainty of compliance with strength verification tests. Tolerable mixes dispatched by a batching plant are +/- 10%, and delays on site can also result in deterioration of the concrete.

6 Long Term Human Health Risk Assessment

6.1 Soils – Long Term Human Health (2015)

Methodology

Based on the Preliminary Risk Assessment and Ground Model for this site, a Generic Quantitative Risk Assessment for human health has been undertaken in accordance with CLR and SR (SC050021 series) (DEFRA) guidance as well as CL:AIRE guidance on Comparing Soil Contamination Data with a Critical Concentration, May 2008 and comprises the following:

- *Selection of appropriate generic screening values for human health assessment.*
- *Creation of relevant datasets from which to undertake the assessment.*
- *Assessment of contamination distribution and comparison of site data to screening values using relevant statistical tests (in accordance with CIEH guidance).*
- *Assessment of risks to receptors.*
- *Determination of requirements for further investigation or remediation.*

Selection of Soil Screening Values

Soil screening values appropriate for a residential (with plant uptake scenario) were selected.

In addition, samples were submitted for chemical analysis for a number of determinants associated with the site former and current use and for which no formal guidance / screening values exist.

Creation of Relevant Datasets

As part of the desk study assessment and Preliminary Conceptual Model, made ground was identified as the principal potential source identified for contamination in the risk evaluation (*Section 2.0*). Consequently the sampling strategy targeted made ground encountered on site.

Assessment

The soil analytical data has been assessed following CL:AIRE/CIEH guidance, CLR11 Model Procedures Section 2.3, and NHBC R&D Publication 66 2008 *"Guidance for the Safe Development of Housing on Land Affected by Contamination"*.

The purpose of human health risk assessment for planning is to decide whether the land is suitable for the proposed end use and does not pose a risk to human health. Therefore, the key question to answer is, *"Is there sufficient evidence that the true mean concentration is less than the critical concentration?"*

Statistics are used to assist in answering the key question raised above and to help decide whether to support a particular hypothesis. The null hypothesis is the starting point because it is believed to be true but needs to be proved.

In terms of planning, the hypotheses are as follows:

- *Null Hypothesis (H0) - the true mean is equal to, or greater than the critical concentration.*
- *Alternative Hypothesis (H1) - the true mean is less than the critical concentration.*

The null hypothesis needs to be rejected in order to confirm that the land does not pose a human health risk and is suitable for use under the planning regime.

Identification of Contaminants of Concern

The results of the soil analysis from the 2015 investigation are shown in *Appendix D*. The chemical results were compared against the relevant GACs for residential with plant uptake end use at 1% soil organic matter (SOM).

Excedances have not been recorded in any of the contaminants tested when compared to the relevant GACs. Asbestos identification was undertaken on all samples with no asbestos material being detected.

It should be noted that the screening values for Aliphatics EC12-16, Aliphatics EC16-35 and Aliphatics EC35-44 are based upon the theoretical lower saturation limit for the compounds in question. The lower saturation limit has been used for these contaminants as the CLEA calculated SGV/GAC is greater than the lower saturation limit and vapour inhalation is an important contributor to exposure (SR4).

Soil screening tables are shown in *Appendix G*.

Discussion

The statistical analysis indicates that the null hypothesis can be rejected for all the contaminants.

Conclusions

The site does not pose a risk to human health, and remediation works are not required as part of the development.

Sutcliffe would however propose to incorporate 300mm of clean imported tested material into all soft landscaped areas to act as a growing medium.

7 Controlled Waters Risk Assessment (2015)

7.1 Methodology

Based on the Preliminary Risk Assessment and Ground Model for this site, a Level 1 Screening Assessment has been undertaken in general accordance with Environment Agency guidance Environment Agency Remedial Targets Methodology, Hydrogeological Risk Assessment for Land Contamination, 2006.

The methodology comprises:

- Identification of potential contaminant linkages.
- Selection of appropriate generic screening values for controlled waters.
 - Screening measured concentrations of leachate against the generic screening values available for UK Drinking Water Standards (UK DWS) and Environmental Quality Standards (EQS).
- Assessment of contaminant distribution and risk to receptors.
 - Identification of contaminants of concern and relevant contaminant linkages.
 - Identification of potential contaminants and contaminant linkages which are no longer of concern.

Identification of Potential Contaminant Linkages

Contaminant linkages have been identified in *Section 3.0* between the made ground and the underlying aquifer via infiltration and/or migration of dissolved phase contaminants.

Selection of Generic Screening Values

Screening values for Drinking Water Standards (DWS) have been used to assess leachability. DWS are relevant to potable receptors (Principal Aquifer).

Environmental Quality Standards (EQS) screening values have been used to assess risks to surface water resources.

Leachate Screening – UK DWS & EQS

Metals and Speciated PAHs were assessed. Exceedances of relevant UK DWS and EQS screening criteria were encountered, details of which are identified in *Table 6.1 & 6.2*. It should be noted that several determinands have limits of detection greater than their respective screening values. Due to the level of

uncertainty associated with such results, these exceedances are not considered significant and are excluded from the table below.

Table 6.1: Leachate Exceedances Summary - DWS

Determinant	DWS Screening Value (µg/l)	Range of concentrations (µg/l)	Location and depth of exceedances
Arsenic	10	11.19	WS2 ES1 0.20-0.50mbgl

Table 6.2: Leachate Exceedances Summary - EQS

Determinant	EQS Screening Value (µg/l)	Range of concentrations (µg/l)	Location and depth of exceedances
Copper	1 to 28	28.42-39.07	WS3 0.20-0.50mbgl – 39.07µg/l WS4 0.20-0.50mbgl – 31.32µg/l TP2 0.20-0.50mbgl – 28.42µg/l

Leachate screening tables are presented in *Appendix G*. Analytical certificates are presented in *Appendix D*.

Contaminant Distributions and Risk to Receptors

Several determinands exceeded the DWS and EQS screening values. However, the risk to controlled waters (groundwater & surface waters) is diminished as a result of the following:

- The site is underlain by a layer of Devensian Till which is classified as Unproductive Strata that will act as an aquiclude impeding the flow of water to the underlying Principal Aquifer.

Conclusion

Exceedances of DWS and EQS screening criteria are not considered significant given the likely depth to groundwater, effects of natural attenuation, lack of nearby groundwater abstractions and the absence of any surface water courses that could be in continuity with ground water beneath the site.

8 Ground Gas Risk Assessment

Gas monitoring wells were installed in 4No exploratory hole locations (WS1, WS2, WS3 & WS4) as part of the 2015 ground investigation completed by Sutcliffe's.

A full copy of all gas monitoring readings and water levels can be found in *Appendix E*.

8.1 Methodology

A ground gas risk assessment has been undertaken in general accordance with the British Standard BS8485:2015, *"Code of Practice for the Characterization and Remediation from Ground Gas in Affected Developments"*.

The guidance is written specifically for use by designers of gas protection measures relating to the development of a site. Reference has also been made to the CIRIA document C665:2007: *"Assessing Risks Posed By Hazardous Ground Gases To Buildings"* and to the Health and Safety Executive document EH40/2005 "Workplace Exposure Limits".

Our assessment comprises the following:

- *Review of results.*
- *Calculation of Gas Screening Values for methane (CH₄) and carbon dioxide (CO₂).*
- *Assessment of risks from ground gas.*
- *Development options.*

8.2 Review of Field Data

Six (6) rounds of gas monitoring have been undertaken. Gas monitoring was undertaken using a fully calibrated GA2000 gas monitor which measured concentrations of oxygen, carbon dioxide and methane as well as gas flow emission rates.

The findings are summarised below and the results are presented in full in *Appendix E*.

Table 7.1: Summarised Ground Gas Monitoring Data

Maximum gas readings encountered during monitoring						
<i>Location</i>	<i>MAX CH₄ (%)</i>	<i>MAX CO₂ (%)</i>	<i>MIN O₂ (%)</i>	<i>MAX P.I.D. (ppm)</i>	<i>Atmospheric Pressure (mb)</i>	<i>MAX Flow Rate (l/hr)</i>
8 th December 2015						
WS1	0.0	0.4	19.8	-	1012	0.0
WS2	0.0	2.0	14.6	-	1012	0.0
WS3	0.0	0.8	16.4	-	1012	0.0
WS4	0.0	0.2	21.1	-	1012	0.0
21 st December 2015						
WS1	0.0	0.2	20.8	-	1002	0.0
WS2	0.0	1.7	18.0	-	1002	0.0
WS3	0.0	0.8	18.3	-	1002	0.0
WS4	0.0	0.1	21.2	-	1002	0.0
6 th January 2016						
WS1	0.1	0.1	21.4	-	984	0.0
WS2	0.2	1.7	18.7	-	984	0.0
WS3	0.2	0.8	19.1	-	984	0.0
WS4	0.1	0.2	21.4	-	984	0.0
21 st January 2015						
WS1	0.1	0.4	15.7	-	1012	+2.1
WS2	0.1	2.3	10.1	-	1012	0.0
WS3	0.1	2.3	6.3	-	1012	0.0
WS4	-	-	-	-	-	-
12 th February 2016						
WS1	0.1	0.3	18.0	-	993	+0.2
WS2	0.1	2.5	10.8	-	993	0.0
WS3	0.1	3.3	5.5	-	993	0.0
WS4	-	-	-	-	-	-
16 th February 2016						
WS1	0.1	0.4	18.8	-	1027	0.0
WS2	0.1	2.1	12.4	-	1027	0.0
WS3	0.1	2.7	5.8	-	1027	0.0
WS4	-	-	-	-	-	-

8.3 Calculation of Gas Screening Values

7.3.1 Methane (CH₄)

Positive concentrations of methane (maximum concentration 0.2%) were recorded during monitoring visits and a worst case flow rate of +2.1l/hr was also recorded. The GSV will be calculated as:

Limiting volume flow rate of gas = gas concentration x measured borehole flow rate

$$= 0.002 \times 2.1 \text{ (gas concentration in table is \%)}$$

$$= 0.0042$$

The GSV therefore classifies the site as Green for Methane.

7.3.2 Carbon Dioxide (CO₂)

Positive concentrations of carbon Dioxide (maximum concentration 3.3%) were recorded during monitoring visits and a worst case flow rate of +2.1l/hr was also recorded. The GSV will be calculated as:

Limiting volume flow rate of gas = gas concentration x measured borehole flow rate

$$= 0.033 \times 2.1 \text{ (gas concentration in table is \%)}$$

$$= 0.0693$$

The GSV classifies the site as Green for Carbon Dioxide.

8.4 Discussion

In accordance with CIRIA C665 the ground gas monitoring results currently indicate that the site has a Gas Screening Value (GSV) of 0.0042l/hr for methane and 0.0693l/hr for carbon dioxide.

This results of this site currently classifiy the site as Green indicating a very low risk from ground gasses. Based on this no protective measures are required.

8.5 Groundwater Protection Measures

There is no evidence at this stage of significant perched water either in the made ground or in the natural stratum encountered on site that would suggest special groundwater protection measures to the building foundations are required.

9 Land Contamination Risks and Remediation Requirements

9.1 Revised Conceptual Model

Based on the findings of the human health, the preliminary conceptual model has been revised and finalised as shown in *Figure 6*. The drawing shows all contaminant linkages from the preliminary conceptual model, identifying those which have been discounted and those which remain relevant.

9.2 Discounted Contaminant Linkages

Controlled Waters – Groundwater & Surface Waters

Groundwater Resources

The UK DWS Leachate screening identified a slightly elevated concentration of Arsenic that is unlikely to cause any risk to the Principal aquifer. The risk is minimised further by the depth of groundwater and the effects of natural attenuation.

Surface Water Resources

The EQS Leachate screening identified three slightly elevated concentrations of Copper that are unlikely to cause a risk to the local surface water features. The nearest surface water feature is noted 139m north of the site, but the levels of identified contaminants are considered to be a low risk to the surface water features.

Long Term Human Health

No elevated levels of contaminants were noted in the soils sampled on site when assessed a 1% SOM screening table for a residential with plant uptake scenario. Therefore the soil on site is not considered to pose a risk to long term human health.

Ground Gas

Based on the results of the gas monitoring the site is classified as Green indicating no gas protection measures are required.

Table 8.1: Summary of Remaining Contaminant Linkages

1. Hazard Identification		2. Hazard Assessment				3. Risk Estimation		4. Risk Evaluation	5. Managing the Risk
Contaminant Source		Pathway		Receptor		Consequence of risk being realised	Probability of risk being realised	Classification	Action required
Table 3.1: Sources		Table 3.2: Receptors		Table 3.3: Pathways					
S1	Made Ground (on site)	P1	Direct contact	R1	Future site users,	Medium	Low	Moderate / Low	The site does pose a risk to human health, and remediation works are not required as part of the development.
		P2	Ingestion	R2	Construction workers	Medium	Low	Moderate / Low	
		P3	Inhalation of dust / vapours	R4	Adjacent site users	Medium	Unlikely	Low	
		P1	Direct contact	R5	Infrastructure / Buried Services	Mild	Unlikely	Very Low	Sutcliffe would however propose to incorporate 300mm of clean imported tested material into all garden and soft landscaped areas to act as a growing medium.
		P5	Vertical and lateral migration of ground gas	R1	Future site users,	Medium	Low	Moderate/ Low	
				R2	Construction Workers	Mild	Low	Low	
				R4	Adjacent	Mild	Low	Low	
				R5	Infrastructure / Buried Services	Mild	Unlikely	Very Low	Based on the results of the gas monitoring the site is classified as Green indicating no gas protection measures are required.

9.3 Additional Works Required to Assess Outstanding Contaminant Linkages

Despite an additional trial pitting exercise in June 2020 to locate the previous foundations / building footprint, no insitu foundations were identified.

9.4 Remediation Requirements

Human Health – Soils

No elevated levels of contaminants were noted on site during the soil sampling exercise carried out in 2015, therefore the soil on site does not pose a risk to human health however Sutcliffe propose 300mm clean imported tested material is incorporated in all garden areas to act as a growing medium.

10 Risk Assessment

10.1 Ground Model

The earliest available historical map (1851) indicated that the site was under agricultural usage. By 1891 Brook House is noted on site (including glass houses) occupying at least 30% of the site, and remained on site until 1938 when the site became undeveloped land. New residential development was noted on site in 1954 noted as Stockmoor Bungalows (prefabricated), which remained on site until 1968-1972 when the development changed to a tower block of flats, noted as Langholme Heights, which remained on site until 2010 when the block was demolished and the site became undeveloped again.

The potential for significant contamination to have arisen at the site as a result of the current and former usage on site is considered to be moderate. However, the possibility of contamination albeit likely to be localised cannot be discounted.

It is understood that the development will consist of residential properties with associated gardens.

The ground comprises between 0.0-2.20m of made ground overlying bands of sands and clays. Groundwater was encountered during the site works in the following exploratory holes:

- WS1 – 3.00m
- WS4 – 0.80m

This groundwater is unlikely to be in continuity with the underlying Principal aquifer.

10.2 Human Health Assessment

Based on the results of the gas monitoring undertaken in 2015 the site is classified as Green indicating no gas protection measures are required.

10.3 Controlled Waters Assessment

Slight exceedances of DWS and EQS screening criteria are not considered significant given the likely depth to groundwater, effects of natural attenuation, dilution factors, protection afforded by the overlying Devensian Till also minimise the risk. The site concentrations detected within the made ground are not considered to pose a significant risk to the Principal Aquifer.

The site is within an Zone 3 SPZ and there are no surface water abstraction licenses within a 500m radius.

11 Recommendations

11.1 Further works

The following actions are recommended:

- Good hygiene practices should be employed during construction work, in addition, the findings of this investigation should be included within the contractors H&S file and an assessment of risks associated with short term human health completed. No consumption of food or smoking should occur without prior hand washing. If dust is encountered, dust masks should be worn and dust suppression employed.
- Design a Phase III Remediation & Validation Proposal for submission to planning department.
- Design SMMP – Management of material on and off site.

References

BRE Special Digest (1991) 'Sulphate and acidic resistance of concrete in the ground' **363**

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Appendix A – General Notes

Generic Notes – Sutcliffe Investigations

Environmental Setting

General

Third party information obtained from the British Geological Survey (BGS), the Coal Authority, the Local Authority etc is presented in the Correspondence Appendix of the Geoenvironmental Report.

Geology, Mining & Quarrying

In order to establish the geological setting of a site, Sutcliffe Investigations refer to BGS maps for the area and the relevant geological memoir.

A coal mining report is obtained from the Coal Authority. Further information is sourced from the Local Authority and by reference to current and historical OS plans.

Landfills

Sutcliffe Investigations obtain data from the Landmark Information Group, the Environment Agency and the Local Authority with respect to known areas of landfilling within 250m of the proposed development site. Reference is also made to historical OS plans, which are inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Radon

Radon is a colourless, odourless gas, which is radioactive. It is formed in strata that contain uranium and radium (most notably granite) and can move through fissures eventually discharging to atmosphere, or the spaces under and within buildings. Where radon occurs in high concentrations, it can pose a risk to health.

In order to assess potential risks associated with radon gas, Sutcliffe Investigations refer to BRE Report BR211, 1999: *“Radon: guidance on protective measures for new dwellings”*.

BR211 provides a preliminary indication of the measures required for a particular site, but it is also often necessary to request a Stage 2 Protective Measures Site Report from the BGS.

The level of protection needed is site-specific and is determined by reference to the radon potential map for the area followed by a geological assessment of the site. This information is contained in the Annexes of BR211.

Annex A – derived from statistical analysis of radon measurements in existing houses carried out by the NRPB and grouped on 5km grid.

Annex B – based on an assessment of the same radon measurements grouped by geological units. The maps show the 5km grid squares underlain completely or in part, by geological units which potentially exceed the action levels for radon protective measures. The grid squares are coded according to highest potential within the square. In many cases the actual geological radon potential varies considerably within a grid square.

Sutcliffe Investigations adopt the following procedure when assessing risk associated with radon.

Firstly, Annex A maps are reviewed to see whether the site requires full, basic or no measures. If the site is in a dark brown square, full radon protection measures are required. If the site is in a light brown square, reference should be made to Annex B.

Secondly, Annex B maps are reviewed to see whether a further geological assessment is required which may result in upgrading the result from Annex A. If a site lies within a shaded square, it may require radon protection and Sutcliffe Investigations request a Stage 2 Protective Measures Site Report from the BGS.

If the site is in a square that is not coloured or shaded in either set of maps then no radon protection is needed and therefore a BGS Report is not normally necessary.

The BGS geological assessment involves checking whether the site is on or close to a geological unit that has statistically been found to have elevated radon potential. The geological assessment is based on either 1:50,000 or the 1:250,000 scale data. The search area specified as part of the request is increased by 50m in areas where 1:50,000 data is available and by 500m in areas with 1:250,000 scale data to allow for potential inaccuracies in the position of boundaries. The BGS report indicates the highest level of protection required within the search area and its buffer zone.

When requesting a BGS report, Sutcliffe Projects select the search radius carefully, since too large a search radius may result in the inclusion of areas underlain by geological units of a higher radon potential, thereby giving rise to recommending too high a level of protection.

The report also includes (where available), a list of the geological units included in the assessment. Sutcliffe Investigations check that these actually underlie the site, rather than the buffer zone only.

On the basis of radon measurements in dwellings and on their geological interpretation, the BGS report stipulates the level of protective measures required for the proposed development site, and this could be:

1. no measures
2. basic measures or
3. full measures

Details of these measures are provided in the Hazardous Gas section of this Geoenvironmental Report.

Hydrogeology

Sutcliffe Investigations obtain information from the Environment Agency (EA) and the Landmark Information Group with respect to:

- groundwater quality
- recorded pollution incidents
- licensed groundwater abstractions

Reference is also made to the EA document "Policy and Practice for the Protection of Groundwater" (1998) and the relevant Groundwater Vulnerability Map.

Bedrock and any overlying granular Drift deposits are classified by the EA.

Major aquifers: *"Highly permeable formations, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public water supply and other purposes".*

Minor aquifers: *"Fractured or potentially fractured rocks which do not have a high primary permeability, or other formations or variable permeability. Although these aquifers will seldom produce large quantities of water for abstractions, they are important both for local supplies and in supplying base flow to rivers".*

Non-aquifers: *"Formations which are generally regarded as containing insignificant quantities of groundwater. However groundwater flow through such rocks, although imperceptible, does take place and needs to be considered in assessing the risk associated with persistent pollutants. Some non-aquifers can yield water in sufficient quantities for domestic use".*

Groundwater vulnerability is determined by 4 variables:

1. The presence and nature of overlying soil (the weathered zone affected by living organisms; soil in the UK can extend up to 2m in depth). Physical properties of the soil affect the downward passage of water and its ability to attenuate pollutants. The EA make reference to a three-fold classification of soil types:-
 - Soils of **low** leaching potential are defined as “soils in which the pollutants are unlikely to penetrate the soil layer because either water movement is largely horizontal, or they have the ability to attenuate diffuse pollutants”.
 - Soils of **intermediate** leaching potential are defined as “soils which have a moderate ability to attenuate diffuse source pollutants or in which it is possible that some non-absorbed diffuse source pollutants and liquid discharges could penetrate the soil layer”.
 - Soils of high leaching potential are defined as “soils with little ability to attenuate diffuse source pollutants and in which non-absorbed diffuse source pollutants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater”.

In urban areas and restored mineral workings the soil information is based on fewer observations than elsewhere. A worst-case vulnerability (H) is therefore assumed for these areas and for current mineral workings by the EA. All are given a designation of **HU** unless proved otherwise.
2. The presence and nature of Drift, which often overlies bedrock. Where Drift is of substantial thickness and low permeability, it can provide an effective barrier to surface pollutant migration. Permeability Drift is classified as a Minor Aquifer except where it is in probable hydraulic continuity with a Major Aquifer, where it is regarded as part of the Major Aquifer unless proven otherwise by site investigation.
3. The nature of the geological strata (bedrock). Rocks that contain groundwater in exploitable quantities are called aquifers.
4. The depth of the unsaturated zone; i.e. that part of the aquifer which lies above the water table.

The EA have also designated Source Protection Zones, which are based on proximity to a groundwater source (springs, wells and abstraction boreholes). The size of a Source Protection Zone may vary from tens to several thousand hectares.

Hydrology

Sutcliffe obtains information from the Environment Agency and the Landmark Information Group with respect to:

- Surface water quality
- Recorded pollution incidents
- Licensed abstractions (groundwater & surface waters)
- Licensed discharge consents
- Site susceptibility to flooding

The EA have set **water quality** targets for all rivers. These targets are known as River Quality Objectives (RQOs). The water quality scheme used to set RQO planning targets is known as the River Ecosystem scheme. The scheme comprises five classes (RE1 to RE5) which reflect the chemical quality requirements of communities of plants and animals occurring in our rivers.

General Quality Assessment (GQA) grades reflect actual water quality. They are based on the most recent analytical testing undertaken by the EA. There are six GQA grades (denoted A to F) defined by the concentrations of biochemical oxygen demand, total ammonia and dissolved oxygen.

The susceptibility of a site to **flooding** is assessed by reference to a Flood Map on the Environment Agency's website. These maps provide shows natural floodplains – areas potentially at risk of flooding if a river rises above its banks or high tides and stormy seas cause flooding in coastal areas.

There are different kinds of area shown on the Flood Map:

1. Dark blue areas could be flooded by the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year, or by a river by a flood that has a 1% (1 in 200) or greater chance of happening each year.
2. Light blue areas show the additional extend of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1% (1 in 1000) chance or occurring each year.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements.

The maps also show all flood defences built in the last five years to protect against river floods with a 1% (1 in 100) chance of happening each year, or floods from the sea with a 0.5% (1 in 200) chance of happening each year, together with some, but not all, older defences and defences which protect against smaller floods.

The Agency's assessment of the likelihood of flooding from rivers and the sea at any location is based on the presence and effect of all flood defences, predicted flood levels and ground levels.

It should also be noted that as the floodplain shown is the 1 in 100 year (or 1 in 200 year as appropriate) areas outside this may be flooded by more extreme floods (e.g. the 1 in 1000 year flood). Also, parts of the areas shown at risk of flooding will be flooded by lesser floods (e.g. the 1 in 5 year flood). In some places due to the shape of the river valley the smaller floods will flood a very similar extent to larger floods but to a lesser depth.

If a site falls within a floodplain, it is recommended that a flood survey be undertaken by a specialist consultant who can advise on appropriate mitigating measures; i.e. raising slab levels, provision of storage etc.

COMAH & Explosive Sites

Sutcliffe Investigations obtain information from the Landmark Information Group with respect to COMAH or explosive sites within 1km of the proposed development site. Sutcliffe Investigations' report refers to any that are present and recommends that the Client seeks further advice from the HSE.

Areas around COMAH sites (chemical plants etc) are zoned with respect to the implementation of emergency plans. The HSE are a statutory consultee to the local planning authority for all COMAH sites. The COMAH site may have to revise its emergency action plan if development occurs. This might be quite straightforward or could entail significant expenditure. Consequently, the COMAH site may object to a proposed development (although it is the Local Authority who have final say and they are likely to place more weight on advice from the HSE).

Preliminary Conceptual Ground Model

The site's environmental setting (and proposed end use) is used by Sutcliffe Investigations to assess the significance of any contamination encountered during the subsequent ground investigation.

Generic Notes – Sutcliffe Geoenvironmental Investigations

2. Ground Investigation Fieldwork

General

Sutcliffe Ground Investigations are undertaken in accordance with current UK guidance including:

- BS5930:1999 “*Code of practice for site investigation*”
- BS10175:2001 “*Code of practice for the identification of potentially contaminated sites*”
- Contaminated Land Reports 1 to 6, most notably CLR Report No. 4 “*Sampling strategies for contaminated land*”
- “*Guidance on the protection soil sampling strategies for land contamination*” – EA R&D Technical report P5-066/TR (2001)
- AGS: 1996 “*Guide to the selection of Geotechnical Soil Laboratory Testing*”

Exploratory hole logs are represented in Appendices to this Geoenvironmental Report. These logs include details of the:

- Investigation technique adopted
- Samples taken
- Descriptions of the solid strata and any groundwater encountered
- Results of any insitu testing
- Any gas/groundwater monitoring well installed

Exploratory Hole Locations

Exploratory hole locations are selected by Sutcliffe Investigations, prior to commencement of fieldwork, to provide a representative view of the strata beneath the site and to target potential contaminant sources identified during the preliminary investigation (desk study). Additional exploratory locations are often determined by the site engineer in light of the ground conditions actually encountered; this enables better delineation of the depth and lateral extent of organic contamination, poor ground, relict structures etc.

Investigation Techniques

Ground conditions can be investigated by a number of techniques; the procedures used are in general accordance with BS5930: 1999 and BS1377: 1990. Techniques most commonly used by Sutcliffe Investigations include:

- Machine excavated trial pits, usually equipped with a backactor and a 0.6m wide bucket
- Cable percussive (Shell & Auger) boreholes, typically using 150mm diameter tools and casing
- Window or windowless sampling boreholes. Constraints associated with existing buildings, operations and underground service runs can render some sites partly or wholly inaccessible to a mechanical excavator. In such circumstances, window sampling is often the most appropriate technique. A window sampling drilling rig can be manoeuvred in areas of restricted access and results in minimal disturbance of the ground (a 150mm diameter tarmac/concrete core can be lifted and put to one side). However, it should be noted that window sampling allows only a limited inspection of the ground (especially made ground with a significant proportion of coarse material).
- Rotary percussive open-hole probeholes are typically drilled using a tricone rock roller bit with air as the flushing medium. Probeholes are generally lined through made ground with temporary steel casing to prevent hole collapse.

Where installed, gas/groundwater monitoring wells typically comprise a lower slotted section, surrounded by a filter pack of 10mm non-calcareous gravel and an upper plain section surrounded in part by a bentonite seal and in part by gravel or arisings. The top of the plain pipe is cut off below ground level and the monitoring well protected by a square, stopcock type manhole cover set in concrete, or the plain pipe is cut off just above ground level and the well protected by 100mm diameter steel borehole helmet set in concrete.

Monitoring well details, including the location of the response zone and bentonite seal are presented on the relevant exploratory hole logs.

Insitu Testing

Where relative densities of granular materials given on the trial pit and window sample logs are based on visual inspection only, they do not relate to any specific bearing capacities. However, wherever possible, Sutcliffe Investigations employ a mackintosh probe to assess relative density. Mackintosh probe results can be related to approximate allowable bearing capacities.

The relative densities of granular materials encountered in cable percussive boreholes are based on Standard Penetration Test (SPT) results. SPTs are carried out boreholes, in accordance with BS 1377 1990, Part 9 Section 3.3. Where full penetration (600mm) is not possible, N values are calculated by linear extrapolation and are shown on the logs as $N^* = x$.

The strength of cohesive deposits is determined using a hand shear vane.

Shear strength test results reported on trial pit logs are considered to be more reliable than those reported on window sample logs. Significant sample disturbance occurs during window sampling and consequently shear strength results on disturbed window samples are generally lower than results obtained during trial pitting, in-situ or in large excavated blocks.

Sampling

Representative soil/fill samples are taken at regular intervals from the exploratory holes to assist in description of the ground and to allow selected laboratory testing to be performed. The type of sample taken is dependent on the nature of the stratum and the purpose of the analysis.

Where the soils encountered contain a significant proportion of coarse grained material, truly representative samples are not typically obtained – only the finer fraction is placed in sample containers. However, a visual estimate of the amount of coarse material is made on site.

NB: Coarse constituents not sampled are defined as: coarse gravel, cobble and boulder (i.e. any 'particles' with an average diameter greater than 20mm).

Occasionally, unrepresentative 'spot' samples are also taken from some exploratory locations for contaminant analysis, typically where unusual, localised pockets of materials are encountered.

Samples of soil for chemical testing are placed into 1 litre plastic tubs prior to delivery to the selected laboratory. Samples of water are taken in one litre brown glass bottles and stored in cool boxes, at a temperature of approximately 4°C, until delivery to the selected laboratory. Soil/fill samples for organic analysis are also stored in cool boxes.

Groundwater

Where encountered during fieldwork, groundwater is recorded on exploratory hole logs. If monitoring wells are installed, groundwater levels are also recorded on one or more occasions after completion of the fieldwork.

It should be borne in mind that the rapid excavation rates used during a ground investigation may not allow the establishment of equilibrium water levels. Water levels are likely to fluctuate with season/rainfall and could be substantially higher at wetter times of the year than those found during this investigation.

Long term monitoring of standpipes or piezometers is always recommended if water levels are likely to have a significant effect on earthworks or foundation design.

Description of Strata

The soils encountered during an Sutcliffe's ground investigation are described (logged) in general accordance with BS 5930. The descriptions and depth of strata encountered are presented on the exploratory hole logs and summarised in the Ground Conditions section within the main body of text.

The materials encountered in the trial pits are logged, samples taken and tests performed on the in-situ materials in the excavation faces, to depths of up to 1.2m; below this depth these operations are conducted at the surface on disturbed samples recovered from the excavation.

Key to Exploratory Hole Logs

Keys to logs are presented in the Appendix(ces) containing the logs. These are two keys – Symbols and Legends and Terms and Definitions.

Health and Safety

All work was carried out in accordance with the procedures detailed in the DGEL Health and Safety Manual and SUKD health and Safety Procedures.

Generic Notes – Sutcliffe Geoenvironmental Investigations

3. Geotechnical Laboratory Tests

General

Soil Samples are delivered to the laboratory for testing along with a schedule of testing drawn up by Sutcliffe Investigations. All tests are carried out in accordance with BS 1377:1990.

The test results are presented as received in an Appendix to this Geoenvironmental Report.

The following laboratory testing are routinely carried out on a selection of samples:

- Atterberg limits & moisture contents
- Soluble sulphate & pH

The additional tests are typically only scheduled where significant earthworks regrade is anticipated:

- Grading
- Compaction tests
- Particle density

Atterberg Limits & Moisture Content

The Liquid and Plastic Limits of samples of natural in-situ clay are determined using the cone penetrometer method and the rolling thread test. These tests enable determination of an average Plasticity Index (PI) for each “type” of clay, although judgement is applied where variable results are reported.

PI can be related to shrinkability (low, medium or high) and then to minimum founding depth. Sutcliffe Investigations typically only consider a soil to be shrinkable if the proportion finer than 63µm is > 35%.

PI results are compared against guidance given in the NHBC Standards, Chapter 4.2 (revised April 2003) which advocates the use of modified Plasticity Index (I’p) defined as:

$$I'p = Ip * (\% < 425\mu m / 100)$$

ie if PI is 30%, but the soil contains 80% < 425µm, then I’p = 30 * 80/100 = 24%

It should be noted that in accordance with the requirements of BS 1377, the % passing the 425µm sieve is routinely reported by testing labs.

Sutcliffe Investigations apply engineering judgement where PI results are spread over a range of classifications. Consideration is given to:

- The average values for each particular soil type (ie differentiate between residual soil and alluvium)
- The number of results in each class and
- The actual values

Unless the judgement strongly indicates otherwise, Sutcliffe Investigations typically adopt a conservative approach and recommend assumption of the higher classification.

Soluble Sulphate and pH

Sulphates in soil and groundwater are the chemical agents most likely to attack sub-surface concrete, resulting in expansion and softening of the concrete to a mush. Another common cause of concrete deterioration is groundwater acidity.

The rate of chemical attack depends on the concentration of aggressive ions and their replenishment at the reaction surface. The rate of replenishment is related to the presence and mobility of groundwater.

Sutcliffe Investigations refer to BRE Special Digest 1 (SD1) "Concrete in aggressive ground. Part 1: Assessing the aggressive chemical environment" (2001). SD 1 provides definitions of:

- The nature of the site (Greenfield, brownfield or pyretic)
- The groundwater regime (static, mobile or highly mobile)
- The Design Sulphate Class (DC Class) and
- The Aggressive Chemical Environment for Concrete (ACEC Class)

Sutcliffe reports clearly state each of the above for the site being considered.

The concentrations of sulphate in aqueous soil/fill extracts are determined in the laboratory using the gravimetric method. The results are expressed in terms of SO_4 for direct comparison with BS 5328:1997. The pH value of each sample was determined by the electrometric method.

SD1 also discusses determination of "representative" sulphate concentration from a number of tests. Essentially if <10 samples of a given soil-type have been tested, the highest measured sulphate concentration should be taken. If >10 samples have been tested, the mean of the highest 20% of the sulphate test can be taken. With respect to groundwater, the highest sulphate concentration should always be taken.

With respect to pH (soil & groundwater) the value used is the lowest value if <10 samples have been tested and the mean of the lowest 20% if >10 samples have been tested.

Generic Notes – Sutcliffe Investigations Geoenvironmental Investigations

4. Contamination Laboratory Analysis & Interpretation (including WAC)

General

An assessment of potential contaminants associated with the former usages of the site is undertaken with reference to CLR 8 “*Potential contaminants for the assessment of land*” and the relevant DETR Industry Profile(s).

Common Inorganic Contaminants

These include:

- Metals, most notably cadmium, copper, chromium, mercury, lead, nickel and zinc
- Semi-metals, most notably arsenic, selenium and (water soluble) boron
- Non-metals, most notably sulphur
- Inorganic anions, most notably cyanides (free & complex), sulphates, sulphides and nitrates

With respect to the terminology used by most analytical laboratories:

Total cyanide = Free cyanide + Complex cyanide

Total cyanide (CN) is determined by acid extraction; whereas free cyanide is the water soluble fraction.

Complex cyanide is “bound” in compounds and is hard to breakdown. Laboratory determination of complex CN involves subjecting the sample to uv digestion for determination of both free and total CN.

Thiocyanate (SCN) is a different species combined with sulphur.

Elemental sulphur (S) and free sulphur are the same. Total sulphur is all forms, including that present in sulphates (SO₄) sulphates etc.

There are 2 forms of chromium (Cr), chromium VI and chromium III. Chromium VI is the more toxic of these. In soils, total chromium is determined by a strong aqua regia acid digestion. Chromium VI is an empirical method based on a water extract test.

Common Organic Contaminants

Petroleum hydrocarbons are a mixture of hydrocarbons produced from the distillation of crude oil. They include aliphatics (alkanes, alkenes and cycloalkanes), aromatics (single or multi benzene ringed compounds) and hydrocarbon-like compounds containing minor amounts of oxygen, sulphur or nitrogen.

Petroleum hydrocarbons can be grouped based on the carbon number range:-

GRO – Gasoline Range Organics (typically C₆ to C₁₀). Also referred to as PRO – Petroleum Range Organics

DRO – Diesel Range Organics (typically C₁₀ to C₂₈)

LRO – Lubricating Oil Range Organics (typically C₂₈ to C₄₀)

MRO – Mineral Oil Range Organics (typically C₁₈ to C₄₄)

However, it should be borne in mind that the terms “GRO” and “DRO” analysis are purely descriptive terms, the exact definition of which varies.

Total Petroleum Hydrocarbons (TPH) is also a poorly defined term; some testing laboratories regard TPH as hydrocarbons ranging from C₅ – C₄₀, whereas others define TPH as C₁₀ – C₃₀.

The composition of a TPH plume migrating through the ground can vary significantly; this is primarily dictated by the nature of the source (eg petrol, diesel, engine oil etc). Furthermore, different hydrocarbons are affected differently by weathering processes and this can result in further variation in the chemical composition of the TPH.

Gasoline contains light aliphatic hydrocarbons rapidly (especially within the C₄ to C₅ range) that will evaporate. The aromatic hydrocarbons in gasoline are primarily benzene, toluene, ethylbenzene and xylenes, referred to as BTEX. Small amounts of polyaromatic hydrocarbons (PAHs) such as benzo(a)pyrene may also be present.

Diesel and light fuel oils have higher molecular weights than gasoline. Consequently, they are less volatile and less water soluble. About 25 to 35% is composed of aromatic hydrocarbons. BTEX concentrations are generally low.

Heavy Fuel Oils are typically dark in colour and considerably more viscous than water. They contain 15 to 40% aromatic hydrocarbons. Polar NSO compounds are also present.

Lubricating Oils are relatively viscous and insoluble in groundwater. They may contain 10 to 30% aromatics, including the heavier PAHs. NSO compounds are also common.

Polycyclic Aromatic Hydrocarbons (PAHs) have more than two fused benzene rings as a structural characteristic. PAH compounds are present in both petrol and diesel, although insignificantly lower concentrations than in coal tars. Certain PAH compounds are carcinogenic (Benzo(a)pyrene) and/or mobile in the environment (naphthalene).

Polychlorinated Biphenyls (PCBs)

Volatile Organic Compounds (VOCs) The volatile organic compound (VOC) headspace concentration of all soil samples was made with a photoionization detector (PID) fitted with a 10.2 eV lamp. This gives a semi-quantitative VOC concentration record as parts per million (ppm) (Vol/Vol). Prior to the VOC headspace reading, the background levels of VOCs were recorded. The PID was recalibrated with standard isobutylene in zero air after every 10 headspace readings.

Semi-Volatile Organic Compounds (sVOCs)

Phenols

Solvents, pesticides, herbicides

Dioxins & furans

Methods of Analysis (Organic Compounds)

Toluene Extractable Matter (TEM) results provide a screening test for organic contamination. The sample is air dried at 30°C and ground prior to addition of the solvent (toluene). The solvent extraction is aggressive and most organic compounds (fuels, oils, tars, humic material, animal fats and vegetable oil) are dissolved, as are some other inorganic contaminants such as sulphur. However, the volatiles (lighter fuel fraction etc) are lost during evaporation of the solvent.

Total Petroleum Hydrocarbon (TPH) by IR (also known as mineral oil by some testing laboratories) is undertaken on "as received" samples. Tetrachloroethylene is the solvent, and fluorosil is used to removed humic material, animal fats and vegetable oil. Consequently this analysis detects a wide range of "mineral" organics from volatiles (BTEX and gasoline) through diesel and oils to tars (including the very heavy, stable tars such as asphalt and bitumen).

TPH by GC-FID is more refined analytical technique which only detects hydrocarbons (aliphatic and aromatic) in the range C₁₀ to C₄₀ (volatiles, heavy tars, humic material and sulphur are not detected). The laboratory can provide a breakdown of the TPH results into diesel range organics (**DRO**) and heavier lubricating oil range organics (**LRO**).

GRO (PRO) by GC-FID analysis detects the more volatile C₆ – C₉ hydrocarbons (aliphatic and aromatic) including those organic compounds present in petrol.

Speciated VOC (by GC-MS) analysis quantifies the concentrations of 30 USA-EPA priority compounds. These include chlorinated alkanes and alkenes (in the molecular weight range chloroethane to tetrachloroethane); trimethylbenzenes; and the 4 BTEX compounds (benzene, ethyl-benzene, toluene & xylene).

Speciated sVOC by (GC-MS) analysis quantifies the concentration of a variety of organic compounds, including the 16 USA-EPA priority PAHs, phenols, 7 USA EPA priority PCB congeners, herbicides & pesticides.

Note: PAHs are hydrocarbons and consequently (where present) will be picked up when scheduling TPH by GC-FID. Naphthalene (the lightest PAH) is also one of the 58 US EPA VOCs.

Speciated TPH by GC-FID provides a “banded” TPH, initially split into aromatic and aliphatic fractions and then further divided into fraction specific carbon bandings based upon behavioural characteristics.

Note: Risk assessment models require physiochemical properties (solubilities, toxicities etc) of compounds in order to model their behaviour in the environment. These physiochemical properties cannot be derived from a single “TPH”, “GRO” or “DRO” value. However, the carbon banded fractions can be used in risk assessment models.

If the relative proportion of each carbon banding within the “TPH” impact at a site is known, the risks posed by each individual fraction can be assessed and a simple back calculation applied to calculate an overall “TPH” screening value based upon the percentage weight fraction of each banding present in the “TPH”. Specialised analytical techniques and data interpretation skills are required to identify each carbon banding.

Current Guidance

The UK approach to the consideration of contaminated land is based upon the principles of risk assessment. This in turn is founded upon the use of so called source⇒ pathway⇒ target principles in order to establish the presence or potential presence of a pollutant linkage.

Sutcliffe Investigations adopt a tiered approach to risk assessment, consistent with UK guidance and best practice. The initial step of such a risk assessment (or Tier 1) is the comparison of site data with appropriate guidance levels, intervention levels or remedial targets.

In March 2002 DEFRA and the Environment Agency published a series of technical research papers (R & D Publications CLR 7, 8, 9 and 10) introducing the UK approach to the assessment of risk to **human health** from land contamination. This methodology and approach represents current scientific knowledge and thinking. The overall methodology also included the Contaminated Land Exposure Model (CLEA) and some Soil Guidance Values (SGV's).

At the time of writing this report, these guidelines only address seven contaminants and the development of both the CLEA model and additional SGV's is ongoing. Where published, SGV's have been utilised as intervention values for the purpose of an initial Tier 1 assessment.

Where SGV's were not published at the time of writing this report, appropriate Tier 1 human health related assessment have been based upon information that was best available at the time of the study.

With respect to the assessment of potential **phytotoxic effects** of contaminants, Sutcliffe Investigations refer to “The Soil Code” (Maff, 1998) for copper and zinc. The CLEA SGV is adopted for nickel.

The potential risk to **building materials** is considered through reference to relevant BRE Digests, with particular emphasis on BRE Special Digest 1, ‘Sulphate and Acid Resistance of Concrete in the Ground’, 2001.

With respect to the interpretation of the calorific values, at present there are no accepted methods to assess whether a sample is combustible and under what circumstances it might smoulder. Some guidance is given in ICRCL Note 61/84 “Notes on the fire hazards of contaminated land” which states that:

“In general it seems likely that materials whose CV's exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn”.

Tier 1 **groundwater** risk assessments are undertaken by comparing leachate concentrations with the appropriate water quality standard. Depending upon the specific characteristics and environmental setting of the site the appropriate standard is likely to be one of the following:

- Water Supply (Water Quality) Regulations 1989
- Environmental Quality Standards (for Freshwater)
- The Surface Waters (Abstraction for Drinking Water) Regulations

The tier 1 risk assessment of **landfill gas** is undertaken through reference to the following documents:

- Approved Document C, Building Regulations 1991
- CIRIA Report 149, “Protecting Development from Methane”, 1995

Should any Tier 1 criteria be exceeded, then three potential courses of action are available. (The first is only applicable in terms of human health, but the second and third could also be applied to groundwater or landfill gas).

- Undertake further statistical following the approach set out in Appendix A of CLR 7 in order to determine whether contaminant concentrations of inorganic contaminants within soil/fill actually present a risk (only applicable to assessing the risk to human health).
- Based on a qualitative risk assessment, advocate an appropriate level of remediation to “break” the pollutant linkage – for example the removal of the contaminated materials or the provision of a clean cover.
- Carry out a more detailed quantitative risk assessment in order to determine whether contamination risks actually exist.

However, the issue of **averaging area** requires further consideration. CLR 7 is ambiguous and could be interpreted as advocating the concept of a single garden as an appropriate averaging area.

This concept has massive implications with respect to ground investigation design and cost. To comply, investigations for residential development on brownfield sites would need to recover and analyse about 6 samples from each garden; this implies exploratory locations on a very tight grid, perhaps 5m to 10m spacings, with a huge increase in the number of samples analysed (cf test schedules currently issued by most practitioners).

In any case, Sutcliffe Investigations consider the concept of a single garden as an averaging area to be inappropriate. Statistical analysis of sample results by fill type, and/or by former use in a given sub-area of the site (i.e. with reference to the Conceptual Site Model), is considered a more appropriate methodology.

Analysis by soil/fill type is appropriate for essentially immobile contaminants associated with a particular fill type, for example arsenic in colliery spoil, metals in ash & clinker, sulphate in plaster-rich demolition rubble etc.

Analysis by former use is appropriate where more mobile contaminants have entered the ground, for example diesel associated with leakage from a former fuel tank, downward migration of leachable metals through granular materials, various soluble contaminants present in a wastewater leaking into the ground via a fractured sewer etc. In these circumstances, it may be appropriate to undertake statistical analysis of sample results from a variety of different soil/fill types. However, consideration would have to be given to factors such as porosity which might influence impregnation of a mobile contaminant into the soil mass; ie contamination would be normally be more pervasive and significant in granular soils than cohesive soils.

There is a suggestion in para 4.7 of CLR 7 that the approach outlined above was intended and the Environment Agency have confirmed that an averaging area can be larger than a single garden, if:

- Contaminant concentrations are within the same statistical population as determined using the maximum value test. The sample data being representative of the averaging area and the mean concentration of the averaging area.
- “Hot spots” are treated as separate zones or averaging areas (as defined by the maximum value test).
- The sampling strategy takes into account uncertainty (spatial heterogeneity) in contaminant concentration

Waste Classification & WAC

In the context of waste soils generated by remediation and/or groundworks activities on brownfield sites, the following definitions (from the Landfill Regulations 2002) apply:

- Inert (e.g. uncontaminated ‘natural soil, bricks, concrete, tiles & ceramics)
- Non-Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances, but at concentrations below prescribed thresholds).
- Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances at concentrations above prescribed thresholds).

Dangerous substances include compounds containing a variety of determinants commonly found in contaminated soils on brownfield sites, for example arsenic, lead, chromium, benzene etc.

From 16th July 2005, landfill operators will require Waste Acceptance Criteria (WAC) laboratory data, if soil is classified as **hazardous** and such waste must have been subjected to pre-treatment. However, subject to WAC testing it may be possible to classify it as stable, non-reactive hazardous waste, which can be placed within a dedicated cell within the non-hazardous landfill.

Sutcliffe Investigations typically only include WAC analysis in site investigation proposals and reports, if significant off-site disposal (of soil classified as hazardous waste) is anticipated for example where redevelopment proposals include basement construction etc.

If off-site disposal of soils classified as hazardous waste were undertaken during redevelopment, then WAC analysis should be scheduled at an early stage in the remediation programme.

However, organic compounds (BTEX, TPH, PAH etc) are the most common contaminants that result in soils being classed as hazardous. These contaminants can often be dealt with by alternative technologies (eg by bioremediation or stabilisation) and consequently retention on site is often possible.

It should be noted that **non-hazardous** soil waste can go to a non-hazardous landfill facility; no further testing (eg WAC) is required.

Generic Notes – Sutcliffe Investigations

5. Hazardous Gas

General

Hazardous gas is considered to be any mixture of potentially explosive, toxic or asphyxiating gases, most notably methane, carbon dioxide and oxygen (deficiency).

In addition, radon, a naturally occurring radioactive gas is also considered. Further information about radon is included in Notes 1 – Environmental Setting.

Assessment of potential risks associated with hazardous gas are based on a review of data obtained from the Landmark information Group, the Environment Agency and the Local Authority and the British Geological Survey.

Reference is also made to historical OS plans, which are inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Where landfilling has occurred within 250m of the site boundary, the Local Planning Authority may request a landfill gas investigation in accordance with the Town and Country Planning General Development Order, 1988.

Sources

Potential sources of hazardous gas are:

- Landfill sites
- Made ground, especially where significant depths are present
- Shallow mineworks associated with coal extraction
- Geological strata, including peat, organic silts, coal-bearing strata and limestone (reaction with acidic waters), granite (radon)
- Groundwater can sometimes act as a “carrier” for hazardous gas
- Leakages from pipelines or storage tanks
- Sewers, septic tanks and cess pits

Generation

Wherever biodegradable material is deposited, landfill gas (principally a mixture of methane and carbon dioxide) is likely to be generated by microbial activity. Carbon dioxide is an asphyxiant and toxic; methane is flammable and a mixture containing between 5% and 15% methane by volume in air is explosive. Landfill gas in the ground is unlikely in itself to pose a significant risk, though it may damage vegetation. However, infiltration of landfill gas into confined spaces (e.g. cellars, services, etc) may give rise to considerable risk.

There is no typical figure for the length of time that landfill gas will be evolved, but at many sites significant gas generation continues for at least 15 years after the last deposit of waste.

Migration

Gas migration from a landfill site may occur in several ways. It may migrate through adjacent strata; the distance of migration being dependent on the pressure gradients, volume of gas and permeability of the strata. Where there are faults, cavities and fissures within the strata, gas may move considerable distances. Other migration pathways for gas include man-made features such as mine shafts, roadways and underground services.

Gas migration is influenced by a number of climatic factors, such as atmospheric pressure variations, water table level variations and the influence of a covering of snow or ice over the surface of the site and surrounding area.

Current Guidance

Guidance on landfill gas monitoring control at landfill sites is given two technical memoranda, Waste Management Paper Nos. 26 and 27 published by the Department of the Environment.

Waste Management Paper 27, 1991 recommends that no dwellings should be constructed within 50m of any landfill that has the capacity to produce large volumes of landfill gas. No garden should extend to within 10m of the landfilled waste. However, development closer to landfill has been permitted where a comprehensive gas risk assessment has been completed (typically based on a minimum of 6 to 12 month monitoring programme) and appropriate gas exclusion measures designed.

The current advice with regard to monitoring for landfill gas is that if the trigger value of 1% volume (20% LEL) for methane and 1.5% volume for carbon dioxide is exceeded then remedial/control measures will be required.

It should be noted that the guideline limit for carbon dioxide of 1.5% volume recommended in Waste Management paper No. 27 is the short term (10 minute) occupational exposure limit for carbon dioxide quoted by the Health and Safety Executive in their publication EH40. The long term (8 hour) occupational exposure limit for carbon dioxide is 0.5% volume.

Approved Document C to the Department of the Environment's Building Regulations 1992 requires what where there may be gaseous contamination of the ground but the level of methane is unlikely to exceed 1% by volume, the ground floor of any house or similar small building shall be constructed of suspended concrete and ventilated as described in BRE Digest Report "Construction of New Buildings on Gas Contaminated Land". The document also requires specific design measures to be taken if a level of 5% volume carbon dioxide exists or is exceeded within the ground.

Although the above guidance is still relevant it has been more recently updated within the following documents published by the Construction Industry Research and Information Association (CIRIA).

CIRIA Report 149	'Protecting Development from Methane' (1995)
CIRIA Report 150	'Methane Investigation Strategies' (1995)
CIRIA Report 151	'Interpreting Measurement of Gas in the Ground' (1995)
CIRIA Report 152	'Risk Assessment for Methane and other gases from the ground' (1995)

The above documents are intended to provide advice on how to investigate and deal with the gas contaminated ground with respect to development.

CIRIA Report 149 characterised sites based on the recorded methane/carbon dioxide concentration and emission rates recorded during a suitable gas investigation. Characteristic situation 1 is deemed to be the lowest risk scenario with the risk rating increasing up to 6. The characteristic situations are classified as follows:

Gassing regime in ground			
Methane (% by volume in air)	Carbon dioxide (% by volume in air)	Emission rate ¹ (m/s)	Characteristic situation ²
< 0.1	< 1.5	not detected	1
> 0.1 – 1	> 1.5 – 5	not detected	2
> 1 - 5	< 5	not detected	3
> 5 – 20	< 20	< 0.01	4
> 20	> 20	> 0.01 – 0.05	5
> 20	> 20	> 0.05	6

Notes:

1. Emission rate values measures as equivalent total gas flow velocity from a 50mm diameter borehole: for methods of measurement see Crowhurst and Manchester (1992).
2. Highest measures parameter used as determining factor.

CIRIA Report 151 (1995) identified that there is currently inadequate guidance on trigger concentrations for ground gases. The current emphasis on using gas concentrations for trigger values particularly in Waste Management Paper 27 and the Building Regulations, should be revised to consider gas pressures, borehole flow rates and estimated surface emission rates.

It was concluded that the most important aspect of relating the gas regime below or adjacent to a site, to the risk it poses to any development, is the surface emission rate i.e. how quickly the gas is coming out of the ground. The lower the surface emission rate the lower the risk. This is considered further in the DETR Partners in Technology Report 'Passive venting of soil gases beneath buildings' (September 1997).

CIRIA Report 149 (1995), reference Table 28, reviewed over 100 case studies of development affected by gas to establish current UK practices for gas control. The report classified the gassing regimes found within 6 Characteristic Situations. The highest measures parameter, either methane or carbon dioxide concentration and/or emission rate were used to define the Characteristic Situation for each case history site. The report then related the typical range of mitigation measures that has been adopted at each study site to the characteristic gas situation.

To achieve a more consistent design of protection measures Table 28 of CIRIA 149 was rewritten (Wilson and Card, 1999) in terms of borehole gas volume flow rate and gas concentrations, as reproduced in the table below. This was done to reflect the importance of recognising the gas surface emission rate.

Characteristic situations based on Gas Flux

Characteristic Situation	Limiting CH ₄ Concentration (% v/v)	Limiting CO ₂ Concentrations (% v/v)	Limiting Borehole Flow Velocity (m/s)	Limiting Borehole Gas Volume Flow (litre/hour)	
				CH ₄	CO ₂
1	< 0.1	< 0.1	< 0.005	< 0.035	< 0.035
2	< 1.0	< 1.5	< 0.005	< 0.35	< 0.5
3	< 5.0	< 5.0	< 0.005	< 1.75	< 1.75
4	< 20	< 20	< 0.01	< 14	< 14
5	> 20	> 20	< 0.05	< 70	< 70
6	> 20	> 20	< 0.05	> 70	> 70

Gas Monitoring Procedure

Sutcliffe Investigations adopt a standard gas monitoring procedure, in accordance with CIRIA guidance. This procedure involves the measurement, in the following order of:

- Atmospheric temperature, pressure and ambient oxygen concentration on site immediately prior to and on completion of monitoring.
- Gas emission rate.
- Methane, oxygen and carbon dioxide concentrations using an infra-red gas analyser.
- Standing water level using a dipmeter.

In addition, ground conditions at each sampling location are recorded together with prevailing weather conditions and any other observations such as any vandalism.

Where samples of gas are required for laboratory analysis, Gresham Tubes are used. Gas concentrations in the well are typically recorded immediately before and after retrieval of a sample.

Appendix B – Ciria Guidance Document C552 2001

RISK ASSESSMENT METHODOLOGY

GENERAL

The purpose of this appendix is to describe in detail the concepts underlying the risk based approach to assessing potentially contaminated land, introduce the roles of key legislation and describe the qualitative methodology adopted for evaluating and characterising risk.

Current best practice in the UK promotes a risk-based approach to dealing with both soil and groundwater contamination. The principal aim of the approach is to ensure protection of human health and the environment in a thorough, transparent and cost-effective manner.

Fundamental to the risk-based approach is the concept that for 'Contaminated Land' to be designated, as a consequence of historic activities, a pathway for contamination must be shown to exist between a source of contamination and a receptor. The combined presence of a source, pathway and a receptor is described as a 'pollutant linkage'.

The concepts associated with a contaminant source, pathway and receptor are defined in DETR Circular 02/2000 'Contaminated Land Environmental Protection Act 1990: Part II A'. A **source** of contamination may be considered as a 'substance, which is in, on or under land that has the potential to cause harm or to cause pollution of controlled waters'. A **receptor** can be considered as either 'a living organism, a group of living organisms, an ecological system or a piece of property which is being, or could be harmed, by a contaminant or controlled waters which are being, or could be, polluted by a contaminant'. A **pathway** may be considered as one or more routes by, or through, which a receptor is being, or could be, exposed to or affected, by a contaminant. Typical pathways may include migration in groundwater, surface water run-off or infiltration, inhalation, dermal contact and ingestion.

The risks posed by an identified pollutant linkage can often be mitigated by removing the source of contamination, treating the source of contamination, blocking the relevant pathway(s) or by protecting the receptor.

PRINCIPLES OF RISK EVALUATION

The risk evaluation methodology presented below is qualitative in nature, and is therefore a subjective method. It is based upon guidance presented in CIRIA publication referenced C552, 'Contaminated land risk assessment - A guide to good practice', 2001 and involves the classification of the following.

The magnitude of the potential **consequence** (severity) of risks occurring (Table 1).

The magnitude of the **probability** (likelihood) of the risk occurring (Table 2).

These are then considered in conjunction to give a risk matrix (Table 3)

Table 1 - Classification of consequence

Classification	Definition	Examples
Severe	Short-term (acute) risk to human health likely to result in “significant harm” as defined by the Environmental Protection Act 1990, Part IIA. Short-term risk of pollution (note: Water Resources Act contains no scope for considering significance of pollution) of sensitive water resource. Catastrophic damage to buildings/property. A short-term risk to a particular ecosystem, or organism forming part of such ecosystem (note the definitions of ecological systems within the Draft Circular on Contaminated Land, DETR, 2000).	High concentrations of cyanide on the surface of an informal recreation area. Major spillage of contaminants from site into controlled water. Explosion, causing building collapse (can also equate to a short-term human health risk if buildings are occupied).
Medium	Chronic damage to Human Health (“significant harm” as defined in DETR, 2000). Pollution of sensitive water resources (note: Water Resources Act contains no scope for considering significance of pollution). A significant change in a particular ecosystem, or organism forming part of such ecosystem. (Note: the definitions of ecological systems within Draft Circular on Contaminated Land, DETR, 2000).	Concentrations of a contaminant from site exceed the generic or site-specific assessment criteria. Leaching of contaminants from a site to a major or minor aquifer. Death of a species within a designated nature reserve.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services (“significant harm” as defined in the <i>Draft Circular on Contaminated Land</i> , DETR, 2000). Damage to sensitive buildings/structures/ services or the environment.	Pollution of non-classified groundwater. Damage to building rendering it unsafe to occupy (e.g. foundation damage resulting in instability).
Minor	Harm although not necessarily significant harm, which may result in a financial loss, or expenditure to resolve. Non-permanent health effects to human health (easily prevented by means such as personal protective clothing etc). Easily repairable effects of damage to buildings, structures and services.	The presence of contaminants at such concentrations that protective equipment is required during site works. The loss of plants in a landscaping scheme. Discolouration of concrete.

Table 2 - Classification of probability

Classification	Definition
High likelihood	There is a pollution linkage and an event that either appears very likely in the short term and almost inevitable over the long term or there is evidence at the receptor of harm or pollution.
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the long term.
Low Likelihood	There is a pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such event would take place, and is less likely in the shorter term.
Unlikely	There is a pollution linkage but circumstances are such that it is improbable that an event would occur even in the very long term.

Table 3 - Comparison of consequence against probability

		Consequence			
		Severe	Medium	Mild	Minor
Probability	High Likelihood	Very High Risk	High Risk	Moderate Risk	Moderate/Low Risk
	Likely	High Risk	Moderate Risk	Moderate/Low Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate/Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate/Low Risk	Low Risk	Very Low Risk	Very Low Risk

Table 4 - Description of the classified risks and likely action required

Very High Risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR, there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not undertaken already) and remediation are likely to be required.
High Risk	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short term and are likely over the longer term.
Moderate Risk	It is possible that harm could arise to a designated receptor from an identified hazard. However, it is relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild. Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.
Low Risk	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Very Low Risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised, it is not likely to be severe.

Table 5 - Response action likely to be required in relation to estimated risk

KEY

	Mitigation and remedial measures required
	Mitigation and remedial measures likely
	Remedial measures unlikely
	Remedial measures not required

RISK ASSESSMENT FOR THE WATER ENVIRONMENT

The risk assessment has been developed to provide a greater level of standardisation. It includes relevant elements from TAG (Transport Analysis Guidance) Table 1 relating to the features described as river, floodplain, groundwater and stillwaters, including their attributes/services and selected/modified indicators of quality and possible measures. Two additional columns have been added for 'grading' and 'importance level'. These columns expand on the limited number of examples provided in TAG Table 2. Table 1 has been developed with reference to TAG, Highways Agency's 'New Approach to Appraisal' (NATA), the Water Framework Directive and other sources as referenced in the table.

Table 1 here relies on easily available data to avoid unnecessary data collection. Should inadequate data be available a 'worst case' should be assumed. The table is designed to act as a guide to determining importance and to raise the level of compatibility in predicting the significance of impacts on the water environment.

Once Table 1 has been used to determine the importance of the environmental attributes that may be affected by a particular development project, Tables 3 and 4 of TAG Unit 3.3.11 can be used to estimate the significance of potential impacts. These tables are reproduced here as Tables 2 and 3 respectively. Table 2 provides a methodology for determining impact magnitude. Table 3 is a matrix that allows the significance of the impact to be calculated based on the impact magnitude and the importance of the attribute. The significance of impacts can range from 'insignificant' to 'very significant'.

**Table 1: Water features, their attributes, indicators of quality, grading and importance
(adapted from Table 1 of TAG unit 3.3.11)**

Feature	Attribute / Service	Indicator of Quality	Measure	Grading	Importance Level
River	Water Supply	Chemical water quality	Environment Agency's Chemical General Quality Assessment (GQA)	A B C-D E-F	Very High High Medium Low
		Industrial / agricultural abstractions	Location and volume of abstraction	All abstractions within 2km downstream: >1000m ³ /day 500-1000m ³ /day 50-499m ³ /day <50m ³ /day	Very High High Medium Low
		Drinking water supply	Classification defined within The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996. No 3001 ²	Classification: DW1 or DW2 within critical travel time for pollution downstream DW3 within critical time downstream Not designated	Very High High Medium - Low
	Biodiversity ³	Biological Water Quality	Environment Agency's Biological GQA ¹	A B C-D E-F	Very High High Medium Low
		Fisheries Quality	Fisheries status as defined within the Freshwater Fish Directive 78/659/EEC	Designated salmonid fishery Designated cyprinid fishery Undesignated fishery Not a fishery	Very High High Medium Low

Feature	Attribute / Service	Indicator of Quality	Measure	Grading	Importance Level
River	Transport and dilution of waste product	Surface Water / effluent discharges	Type of discharges with reference to the EC Dangerous Substances Directive (76/464/EEC and Daughter Directives)	All discharges within 2km up or downstream: List I List II Other discharge / no discharge	Very High - High Medium Medium - Low
	Recreation	Riverside access	Presence / absence of route and importance	National trail / cycleway Regional trail Definitive footpath / bridleway No route	Very High High Medium Low
		Presence of clubs/ recreation use	Presence / absence	Club recreation use present No club / recreation use	Very High - High - Medium Low
	Conveyance of flow and material	Presence of water courses	Size of watercourses ⁵	Main River > 10m wide Main River < 10m wide Ordinary watercourse >5m wide Other	Very High High Medium Low
Floodplain	Flood defence	Importance in relation to flood defence	Status of flood plain area	Designated washland Active floodplain Existing defended area Does not flood	Very High High Medium Low
			Return period	> (ie more frequent then) 1 in 25 years < 1 in 25 years <1 in 100 years (urban) <1 in 50 years <1 in 200 years	Very High High Medium Medium Low
Groundwater	Water supply	Industrial / agricultural abstractions	Location and volume of abstraction	All abstraction points within zone of influence of development: >1000m3/day >500-1000m3/day 50-499m3/day <50m3/day	Very High High Medium Low
		Drinking water supply	Presence of potable public supply or private water supply within zone of influence of development	Public supply Private water supply >10m3/day or serves >50 people ⁶ Other private water supply No supply	Very High High Medium Low
		Groundwater vulnerability	Source protection status	Within zone 1,2 or 3 of a source protection zone Not within a source protection zone	Very High High Medium Low
			Classification of aquifer vulnerability	Major aquifer with H soils or I soils or U soils. Minor aquifer with H soils or U soils Major aquifer with L soils. Minor aquifer with L soils or non aquifer	Very High High Medium Low
	Conveyance of flood flows	Acceptance potential of flood flows	Soil type / groundwater table levels ⁸	Gravels with low water table (>1m below infiltration point) Sands with low water table All soil types with high water table Clay	Very High High Medium Low
Stillwaters (lakes and ponds)	Biodiversity ³	Biological water quality	Classification system to be developed under the Water Framework Directive for ecological status / potential		
		Fisheries quality	Fisheries status as defined within the Freshwater Fish Directive 78/659/EEC	Designated salmonid fishery Designated cyprinid fishery Undesignated fishery Not a fishery	Very High-high High - medium Medium - low Low
	Water supply	Use for abstraction	Presence / absence	Abstraction	Very High - High – Medium ⁹
				No abstraction	Low
	Recreation	Presence of clubs / recreation use	Presence / absence	Club recreation use present No club / recreation use	Very High - High - Medium ⁴ Low

Notes to Table 1

- 1 If the river is unclassified and hence has no GQA grade, the quality can be measured or assumptions can be made based on the grade of the nearest classified stretch.
- 2 An importance level of high or very high must also be awarded if the water feature provides more than 10m³/day of drinking water, or serves more than 50 people, which is the definition used in the Water Framework Directive to define drinking water protected areas.
- 3 Conservation value is not included, as this should be included within an ecology/nature conservation assessment.
- 4 This required judgement on a case by case basis because the importance of use by people is being assessed, and they are sensitive to being categorised as unimportant. Careful assessment is thus required, using as much data as possible eg on the facilities, their scale and frequency of use, membership levels and economic value.
- 5 An importance level of 'Medium' or greater must also be awarded if a river has a catchment greater than 10km², as this means that it will be classified as a water body under the Water Framework Directive. Other measures are available for describing the ability of watercourses to convey flow and material (such as the carrying capacity of the channel for flood flows) and could if necessary be substituted.
- 6 Based on criteria given within the Water Framework Directive for features to be designated as drinking water protected areas.
- 7 Adapted from NRA Policy and Practice for the Protection of Groundwater, Groundwater Vulnerability Sheets, NRA 1994. Because soil information in urban areas is less reliable and based on fewer observations than in rural areas, the worst case is assumed and such land is classified as being high of leaching potential. H = high, I = Intermediate, L = Low and U = Unclassified leaching potential.
- 8 This uses a coarse basis of permeability together with the ability of the existing ground conditions to accept additional flows. For example, gravels in a river floodplain are unlikely to have a high acceptance potential because of raised water table due to river flows. Sands above a relatively dry substrata would have a high potential, however caution is required in areas such as chalk with highly fluctuating groundwater levels.
- 9 Depends on use of water, volume abstracted etc. An importance level of 'High' or 'Very high' must be awarded if the water feature provides more than 10m³/day of drinking water, or serves more than 50 people, which is the definition used in the Water Framework Directive to define drinking water protected areas.

Table 2: Criteria for determining impact magnitude (reproduced from Table 3 of TAG unit 3.3.11)

Magnitude	Criteria	Example
Major	Results in loss of attribute	- Loss of EC designated Salmonid fishery - Compromise employment source - Pollution of potable source of abstraction - Change in GQA grade of river reach - Loss of flood storage / increased flood risk
Moderate	Results in impact on integrity of attribute or loss of part of attribute	- Loss in productivity of a fishery - Contribution of a significant proportion of the effluent in the receiving river, but insufficient to change its GQA grade - Reduction in the economic value of the feature
Minor	Results in minor impact on attribute	Measurable change in attribute, but of limited size and/or proportion
Negligible	Results in an impact on attribute but of insufficient magnitude to affect the use / integrity	- Discharges to watercourse but no significant loss in quality, fishery productivity or biodiversity - No significant impact on the economic value of the feature - No increase in flood risk

**Table 3: Significance Criteria of Potential Impacts
(Reproduced from Table 4 of TAG unit 3.3.11)**

Magnitude of Potential impact	Importance of Attribute			
	Very High	High	Medium	Low
Major	Very Significant	Very Significant	Significant	Low Significant
Moderate	Very Significant	Significant	Low Significant	Insignificant
Minor	Significant	Low Significant	Insignificant	Insignificant
Negligible	Low Significant	Insignificant	Insignificant	Insignificant

Table 4: Proposed impact assessment summary table

Feature	Attribute / Service	Importance Level	Magnitude of Impact	Significance of Impact
River	Water Supply	Very High	Minor	Significant

References

- 1 The Highways Agency et al, Design Manual for Roads and Bridges, Vol 11. Environmental Assessment, 1993.
- 2 DETR 'Guidance on the New Approach to Appraisal, 1998.
- 3 Department for Transport, Transport Analysis Guidance (TAG) 2003

Appendix C –Window Sample, Trial Pit and Cable Percussion Logs



Sutcliffe Investigations

Site Langholme Heights, West Derby	Number WS1
Excavation Method Drive-in Window Sampler	Client Cobalt Housing
Dimensions	Job Number 27601LG
Location	Engineer AT
Dates 25/11/2015	Sheet 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
0.20-0.50	E1				(0.50)	Grass over MADE GROUND (black ashy fine to medium grained SAND with fine to coarse concrete and brick fragments)			
1.00-1.45	SPT N=12		2,2/2,2,4,4		0.50	Stiff brown sandy gravelly CLAY. Sand is fine Gravel is fine to medium subrounded to angular and of mixed lithology			
2.00-2.45	SPT N=18		3,4/4,4,4,6		(2.50)				
3.00-3.45	SPT N=7		Water strike(1) at 3.00m, no rise after 20 mins. 4,3/2,1,2,2		3.00	Loose brown fine to medium grained SAND			
4.00-4.45	SPT N=21		4,4/4,4,6,7		(1.00)				
5.00-5.45	SPT N=12		3,2/3,3,3,3		4.00	Stiff brown sandy gravelly CLAY. Sand is fine Gravel is fine to medium subrounded to angular and of mixed lithology			
					(0.50)	Medium dense brown fine to medium grained SAND			
					(0.95)				
					5.45	Complete at 5.45m			

Remarks	Scale (approx) 1:50	Logged By AT
	Figure No. 27601LG.WS1	

 Sutcliffe Investigations						Site Langholme Heights, West Derby		Number WS2	
Excavation Method Drive-in Window Sampler		Dimensions		Ground Level (mOD)		Client Cobalt Housing		Job Number 27601LG	
		Location		Dates 25/11/2015		Engineer AT		Sheet 1/1	
Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
0.20-0.50	E1				(0.50)	Grass over MADE GROUND (black ashy fine to medium grained SAND with fine to coarse concrete and brick fragments)			
					0.50 (0.20) 0.70	MADE GROUND (brown sandy CLAY with fine to medium brick fragments. Sand is fine to medium)			
1.00-1.45	SPT N=9		1,1/1,1,3,4			Stiff (locally firm) brown with grey veining slightly sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology			
2.00-2.45	VANE 130kPa SPT N=15		3,3/3,4,4,4						
2.90-3.45	VANE 130kPa SPT N=21		2,3/4,4,6,7		(4.75)				
3.20	VANE 130kPa								
3.90-4.45	VANE 130kPa SPT N=21		3,3/4,4,6,7						
4.20	VANE 70kPa								
4.90-5.45	VANE 60kPa SPT N=20		3,4/4,4,5,7		5.45				
						Complete at 5.45m			
Remarks Borehole dry							Scale (approx) 1:50	Logged By AT	Figure No. 27601LG.WS2



Sutcliffe Investigations

Site Langholme Heights, West Derby						Number WS3			
Excavation Method Drive-in Window Sampler		Dimensions		Ground Level (mOD)		Client Cobalt Housing		Job Number 27601LG	
		Location		Dates 25/11/2015		Engineer AT		Sheet 1/1	
Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
0.20-0.50	E1				(0.60)	Grass over MADE GROUND (black ashy fine to medium grained SAND with fine to coarse concrete and brick fragments)			
1.00-1.45	SPT N=11		3,3/2,3,3,3		0.60 (0.40) 1.00	MADE GROUND (brown sandy gravelly CLAY. Sand is fine Gravel is fine to medium subangular to angular and of mixed lithology) - reworked material			
2.00-2.45	SPT N=12		1,2/3,3,3,3			Stiff brown with grey veining slightly sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology			
3.00-3.45	SPT N=20		2,3/3,5,6,6		(4.45)				
4.00-4.45	SPT N=23		4,4/5,5,6,7						
5.00-5.45	SPT N=20		4,4/4,5,5,6		5.45	Complete at 5.45m			
Remarks Borehole Dry							Scale (approx) 1:50	Logged By AT	
							Figure No. 27601LG.WS3		

 Sutcliffe Investigations						Site Langholme Heights, West Derby		Number WS4	
Excavation Method Drive-in Window Sampler		Dimensions		Ground Level (mOD)		Client Cobalt Housing		Job Number 27601LG	
		Location		Dates 25/11/2015		Engineer AT		Sheet 1/1	
Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
0.20-0.50	E1				(0.10) (0.10) (0.30) 0.40	Grass over dark brown gravelly fine to coarse grained SAND with root material. Gravel is fine to medium subangular to subrounded and of mixed lithology (TOPSOIL)			
1.00-1.45	SPT N=21		Water strike(1) at 0.80m, no rise after 20 mins. 3,4/5,5,5,6		(0.60) 1.00	MADE GROUND (brown sandy gravelly CLAY with fine to medium brick fragments. Sand is fine Gravel is fine to medium subangular to angular and of mixed lithology) - reworked material		▼1	
2.00-2.45	SPT N=20		3,3/4,5,5,6			MADE GROUND (black ashy fine to medium grained SAND with pockets of fine to medium brick fragments and light brown sandy CLAY)			
3.00-3.45	SPT N=19		3,3/3,4,6,6		(4.00)	Stiff brown with grey veining slightly sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology			
4.00-4.45	SPT N=19		3,3/3,4,6,6						
5.00-5.45	SPT N=16		4,4/4,4,4,4		5.00 (0.20) 5.20 (0.25) 5.45	Medium dense brown fine to medium grained SAND			
						Stiff brown with grey veining slightly sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology			
						Complete at 5.45m			
Remarks							Scale (approx)	Logged By	
							1:50	AT	
							Figure No.		
							27601LG.WS4		



Langholme Heights, West Derby

**Trial Pit
Number**
TP1

Trial Pit

Dimensions

Dates	25/11/2015
--------------	------------

Cobalt Housing

**Job
Number**
27601LG

AT

Sheet
1/1

Depth
(m)

Sample / Tests

Water
Depth
(m)

Field Records

Level
(mOD)Depth
(m)
(Thickness)

Description

Legend

Water

Grass over MADE GROUND (black ashy fine to medium grained SAND with fine to coarse concrete and brick fragments)
Gas main at 0.40m

Gas main at 0.40m

MADE GROUND (brown slightly sandy slightly gravelly CLAY. Sand is fine Gravel is fine to medium subangular to subrounded and of mixed lithology) - reworked material
600mm Concrete service at 0.60m - Water or Gas main

Stiff brown slightly sandy slightly gravelly CLAY. Sand is fine Gravel is fine to medium subangular to subrounded and of mixed lithology

Complete at 2.00m

Plan

Remarks

Trial Pit Dry

Scale (approx)

1:50

Logged By

AT

Figure No.

27601LG.TP1



Sutcliffe Investigations

Excavation Method

Trial Pit

Site

Langholme Heights, West Derby

Trial Pit Number

TP2

Client

Cobalt Housing

Job Number

27601LG

Engineer

AT

Sheet

1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
1.50	VANE 130kPa				0.50	Grass over MADE GROUND (black ashy fine to medium grained SAND with fine to coarse concrete and brick fragments) Concrete slab at 0.40m		
1.80	VANE 130kPa				1.50	Stiff brown with grey veining slightly sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology Land drain at 1.20m	 	
2.00	VANE 130kPa				2.00	Complete at 2.00m		

Plan

Remarks

Trial pit dry - water ingressing from broken land drain

Scale (approx)

1:50

Logged By

AT

Figure No.

27601LG.TP2



Sutcliffe Investigations

Excavation Method

Trial Pit

Site

Langholme Heights, West Derby

Trial Pit Number

TP4

Dimensions

Ground Level (mOD)

Client

Cobalt Housing

Job Number

27601LG

Location

Dates

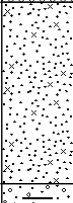
25/11/2015

Engineer

AT

Sheet

1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
1.35	VANE 78kPa				(0.10)	Grass over dark brown gravelly fine to coarse grained SAND with root material. Gravel is fine to medium subangular to subrounded and of mixed lithology (TOPSOIL)		
1.50	VANE 82kPa			0.10				
				(0.50)				
					0.60	MADE GROUND (black ashy fine to medium grained SAND with pockets of fine to medium brick fragments and light brown sandy CLAY)		
				(1.20)	Firm dark grey very sandy CLAY. Sand is fine to medium			
1.90	VANE 130kPa				1.80	Stiff brown with grey veining slightly sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology		
2.00	VANE 130kPa			(0.20)				
				2.00	Complete at 2.00m			

Plan

Remarks

Scale (approx)

1:50

Logged By

AT

Figure No.

27601LG.TP4



Langholme Heights, West Derby

**Trial Pit
Number**
TP5

Trial Pit

Dimensions

Dates	25/11/2015
--------------	------------

Cobalt Housing

Job Number
27601LC

Location

AT

Sheet
1/1

Depth
(m)

Sample / Tests

Water
Depth
(m)

Field Records

Level
(mOD)Depth
(m)
(Thickness)

Description

Legend

Water

Grass over dark brown gravelly fine to coarse grained SAND with root material. Gravel is fine to medium subangular to subrounded and of mixed lithology (TOPSOIL)

MADE GROUND (light brown and dark brown sandy CLAY with rebar and whole bricks. Sand is fine to medium)

MADE GROUND (stiff brown sandy gravelly CLAY. Sand is fine Gravel is fine to medium subrounded to angular and of mixed lithology) - Reworked material

Stiff brown sandy gravelly CLAY. Sand is fine Gravel is fine to medium subrounded to angular and of mixed lithology
Drain at 1.00m

Complete at 1.80m

Plan

Remarks

Trial Pit dry

Scale (approx)

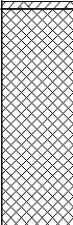
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Logged By

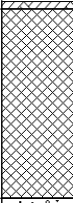
AT

Figure No.

27601LG.TP5

 Sutcliffe Investigations					Site Langholme Heights		Trial Pit Number TP101	
Excavation Method Trial Pit		Dimensions		Ground Level (mOD)		Client Cobalt Housing		Job Number 31044LG
		Location		Dates 08/06/2020		Engineer AT		Sheet 1/1
Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					0.05 (1.45) 1.50 (0.20) 1.70	Grass over dark brown fine to medium grained SAND with root material (TOPSOIL) MADE GROUND (Grey brown fine to medium grained SAND with fine to coarse concrete brick rebar plastic and wood fragments some large (1000x500mm) concrete blocks) Brown very sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular to subrounded and of mixed lithology Complete at 1.70m	 	
						Remarks Trail pit dry No evidence of insitu foundations		
North 						Scale (approx) 1:50	Logged By AT	Figure No. 31044LG.TP101

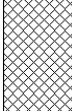
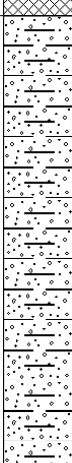
 Sutcliffe Investigations					Site Langholme Heights		Trial Pit Number TP102	
Excavation Method Trial Pit		Dimensions		Ground Level (mOD)		Client Cobalt Housing		Job Number 31044LG
		Location		Dates 08/06/2020		Engineer AT		Sheet 1/1
Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					0.05	Grass over dark brown fine to medium grained SAND with root material (TOPSOIL)		
					(0.95)	MADE GROUND (Grey brown fine to medium grained SAND with fine to coarse concrete brick rebar plastic and wood fragments)		
					1.00	Red brown slightly friable sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular to subrounded and of mixed lithology		
					(0.30) 1.30			
						Complete at 1.30m		
					Remarks Trail pit dry No evidence of insitu foundations			
					North  Scale (approx) 1:50 Logged By AT Figure No. 31044LG.TP102			

 Sutcliffe Investigations					Site Langholme Heights		Trial Pit Number TP103	
Excavation Method Trial Pit		Dimensions		Ground Level (mOD)		Client Cobalt Housing		Job Number 31044LG
		Location		Dates 08/06/2020		Engineer AT		Sheet 1/1
Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					0.05 (1.25) 1.30 (0.20) 1.50	Grass over dark brown fine to medium grained SAND with root material (TOPSOIL) MADE GROUND (brown fine to medium grained SAND with fine to coarse concrete brick and rebar fragments) Red brown slightly friable slightly silty sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular to subrounded and of mixed lithology Complete at 1.50m	 	
					Remarks Trail pit dry No evidence of insitu foundations			
					North 	Scale (approx) 1:50	Logged By AT	Figure No. 31044LG.TP103

 Sutcliffe Investigations					Site Langholme Heights		Trial Pit Number TP104	
Excavation Method Trial Pit		Dimensions		Ground Level (mOD)		Client Cobalt Housing		Job Number 31044LG
		Location		Dates 08/06/2020		Engineer AT		Sheet 1/1
Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					0.05	Grass over dark brown fine to medium grained SAND with root material (TOPSOIL)		
					(0.75)	MADE GROUND (grey fine to coarse grained SAND with graded granular limestone brick and concrete fragments)		
					0.80	Red brown slightly friable slightly silty sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular to subrounded and of mixed lithology		
					(0.80)			
					1.60	Complete at 1.60m		
					Remarks Trail pit dry No evidence of insitu foundations			
					North  Scale (approx) 1:50 Logged By AT Figure No. 31044LG.TP104			

 Sutcliffe							Site Langholme Heights		Borehole Number BH101	
Boring Method Cable Percussion		Casing Diameter			Ground Level (mOD)		Client Cobalt Housing		Job Number 31044LG	
		Location			Dates 15/10/2021		Engineer AT		Sheet 1/2	
Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	
1.20-1.65	SPT N=16			3,4/4,4,4,4		0.10	Grass over dark brown fine to medium grained SAND with root material (TOPSOIL)			
						(0.90)	MADE GROUND (black ashy fine to medium grained SAND with fine to coarse concrete and brick fragments)			
2.00-2.45	SPT N=12			4,4/3,3,3,3		1.00	Stiff brown slightly sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular to subrounded and of mixed lithology			
						(3.00)				
3.00-3.45	SPT N=11			4,3/2,3,3,3						
4.00-4.45	SPT N=10			2,2/3,2,3,2		4.00	Stiff brown with grey veining slightly sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology			
						(1.90)				
5.00-5.45	U1			15 blows						
6.00-6.45	SPT N=19			4,4/5,5,4,5		5.90	Very stiff brown sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology			
7.50-7.95	SPT N=23			3,5/5,6,6,6						
9.00-9.45	SPT N=21			3,3/4,5,6,6		(6.10)				
Remarks								Scale (approx)	Logged By	
								1:50	AT	
								Figure No. 31044LG.BH101		

							Site Langholme Heights		Borehole Number BH101	
Boring Method Cable Percussion		Casing Diameter			Ground Level (mOD)		Client Cobalt Housing		Job Number 31044LG	
		Location			Dates 15/10/2021		Engineer AT		Sheet 2/2	
Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	
10.00-10.45	U*2			25 blows			cont....Very stiff brown sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology			
12.00-12.45	SPT N=23			6,6/5,5,6,7		12.00	Very stiff brown laminated slightly sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine subangular to subrounded and of mixed lithology			
						(1.10)				
13.50-13.95	SPT N=21			4,5/5,5,6,5		13.10	Very stiff brown slightly sandy slightly gravelly CLAY. Sand is fine Gravel is fine to medium subangular to subrounded and of mixed lithology			
						(1.00)				
15.00-15.43	SPT 50/275			Water strike(1) at 14.00m, rose to 13.00m in 20 mins, sealed at 12.50m.		14.10	Very stiff brown sandy gravelly CLAY. Sand is fine Gravel is fine to medium subangular to subrounded and of mixed lithology			
						(4.09)				
16.50-16.85	SPT 50/200			9,10/14,18,18						
18.00-18.19	SPT 25*/85 50/105			20,5/28,22		18.19	Complete at 18.19m			
Remarks								Scale (approx) 1:50	Logged By AT	Figure No. 31044LG.BH101

							Site Langholme Heights		Borehole Number BH102			
Boring Method Cable Percussion		Casing Diameter			Ground Level (mOD)		Client Cobalt Housing		Job Number 31044LG			
		Location			Dates 16/10/2021- 17/10/2021		Engineer AT		Sheet 1/2			
Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water			
1.20-1.65	SPT N=9			1,2/2,2,3,2		(0.20)	Grass over dark brown fine to medium grained SAND with root material (TOPSOIL)					
						0.20	MADE GROUND (black ashy fine to medium grained SAND with fine to coarse concrete and brick fragments)					
(0.90)												
1.10	Stiff brown with grey veining slightly sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology											
2.00-2.45	SPT N=14			2,2/3,4,4,3								
3.00-3.45	SPT N=14			3,3/3,4,3,4								
5.00-5.45	U1			14 blows								
7.50-7.95	SPT N=19			4,5/5,5,5,4								

 Sutcliffe							Site Langholme Heights		Borehole Number BH102	
Boring Method Cable Percussion		Casing Diameter			Ground Level (mOD)		Client Cobalt Housing		Job Number 31044LG	
		Location			Dates 16/10/2021-17/10/2021		Engineer AT		Sheet 2/2	
Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	
10.00-10.45	U*2			20 blows			cont...Very stiff brown sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology			
12.00-12.45	SPT N=17			4,5/5,4,4,4						
						13.10	Very stiff brown very sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular to subrounded and of mixed lithology		▼ ₁ ▽ ₁	
						(1.30)				
13.50-13.85	SPT 50/200			Water strike(1) at 13.50m, rose to 12.80m in 20 mins, sealed at 12.80m. 8,10/16,16,18			Very stiff brown sandy gravelly CLAY. Sand is fine Gravel is fine to medium subangular to subrounded and of mixed lithology			
						14.40				
15.00-15.36	SPT 50/205			8,11/15,15,20						
						(3.73)				
16.50-16.70	SPT 25*/85 50/115			18,7/22,28						
						18.13				
18.00-18.13	SPT 25*/30 50/95			25/32,18			Complete at 18.13m			
Remarks								Scale (approx)	Logged By	
								1:50	AT	
								Figure No. 31044LG.BH102		



Sutcliffe

Site
Langholme Heights

Borehole Number
BH103

Boring Method Cable Percussion	Casing Diameter		Ground Level (mOD)	Client Cobalt Housing	Job Number 31044LG
	Location		Dates 16/10/2021	Engineer AT	Sheet 1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
1.20-1.65	SPT N=7			1,1/1,2,2,2		0.10 (0.50) 0.60 (1.00) 1.60	Grass over dark brown fine to medium grained SAND with root material (TOPSOIL) MADE GROUND (black ashy fine to medium grained SAND with fine to coarse concrete and brick fragments) MADE GROUND (brown slightly sandy slightly gravelly CLAY with fine to medium rebar brick and concrete fragments. Sand is fine Gravel is fine to medium subangular to subrounded and of mixed lithology) - reworked material		
2.00-2.45	SPT N=7			1,1/1,2,2,2			Firm to stiff brown with grey veining slightly sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology		
3.00-3.45	U1			18 blows					
4.50-4.95	SPT N=14			2,2/3,3,4,4					
5.00-5.45	U2			26 blows					
6.50-6.95	SPT N=14			2,3/3,3,4,4		(8.35)			
8.00-8.45	SPT N=16			3,3/4,4,4,4					
9.50-9.95	SPT N=23			5,5/5,6,6,6		9.95			

Remarks	Scale (approx)		Logged By
	1:50		AT
	Figure No. 31044LG.BH103		

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
11.00-11.45	SPT N=26			5,5/6,6,7,7		(1.85)	Very stiff brown with grey veining slightly sandy slightly gravelly CLAY. Sand is fine to medium Gravel is fine to medium subangular and of mixed lithology		▼
									
12.50-12.95	SPT N=26			Water strike(1) at 11.80m, rose to 11.10m in 20 mins, sealed at 12.10m. 5,5/6,6,7,7		11.80	Very stiff brown laminated slightly sandy slightly gravelly CLAY. Sand is fine Gravel is fine subangular to subrounded and of mixed lithology		▽
						(0.80)			
						12.60	Very stiff brown sandy gravelly CLAY. Sand is fine Gravel is fine to medium subangular to subrounded and of mixed lithology		
									
14.00-14.45	SPT N=30			6,7/7,7,8,8					
15.00-15.45	SPT N=50			9,9/9,11,18,12		(4.79)			
									
16.50-16.95	SPT N=46			10,14/11,16,16,3					
17.00-17.39	SPT 50/237			8,17/20,30		17.39	Complete at 17.39m		
									

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Appendix D – Analytical Certificates



Test Certificate

Client: Sutcliffe
18-20 Harrington Street, Liverpool, L2 9QA
Site: Langholme Heights - Ref 27601

Date Tested: 30/11/15
Date Reported: 4 December, 2015
Date Received: 27 November, 2015
Sample Type: Solid

Certificate No: 15/5973/G/S/C1
File No: 15/5973/G/S
Client Ref: No order supplied

Lab sample ref:	C227315	C227316	C227317	C227318	C227319
Client sample ref:	WS1 ES1 0.20-0.50m	WS2 ES1 0.20-0.50m	WS3 ES1 0.20-0.50m	WS4 ES1 0.20-0.50m	TP2 ES1 0.20- 0.50m
Date sampled:	25/11/15	25/11/15	25/11/15	25/11/15	25/11/15
Sample matrix:	S	S	S	S	S

Determinand	Method	Units	ISO17025	MCERTS	LOD					
Deviation Assessment										
Deviation(s)	C. Review	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Metals (Leachate)										
Arsenic leachable	AN47e	µg/l	Y	N	0.25	8.27	11.19	6.00	2.16	3.11
Boron leachable	AN47k	µg/l	Y	N	4	26.19	19.99	20.42	22.22	21.99
Cadmium leachable	AN47a	µg/l	Y	N	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium leachable	AN47a	µg/l	Y	N	0.05	0.95	1.10	0.80	0.69	1.08
Copper leachable	AN47b	µg/l	Y	N	0.1	17.75	24.76	39.07	31.32	28.42
Lead leachable	AN47a	µg/l	Y	N	0.05	0.13	0.98	0.65	1.47	0.30
Mercury leachable	AN47a	µg/l	Y	N	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel leachable	AN47b	µg/l	Y	N	0.1	0.72	0.95	1.68	1.99	1.01
Selenium leachable	AN47c	µg/l	Y	N	1	2.38	<1.00	<1.00	<1.00	<1.00
Zinc leachable	AN47g	µg/l	Y	N	0.5	1.2	1.4	5.4	3.1	1.9
Metals (soil)										
Arsenic	AN8b	mg/kg	Y	Y	2	12	13	11	7	6
Boron (water soluble)	AN03	mg/kg	Y	N	0.5	0.9	1.0	0.9	0.8	0.7
Cadmium	AN8a	mg/kg	Y	Y	1	<1	<1	<1	<1	<1
Chromium (III)	AN8b	mg/kg	Y	Y	2	22	22	22	27	25
Copper	AN8b	mg/kg	Y	Y	2	42	42	56	41	22
Lead	AN8b	mg/kg	Y	Y	2	59	62	81	55	32
Mercury	AN8a	mg/kg	Y	Y	1	<1	<1	<1	<1	<1
Nickel	AN8b	mg/kg	Y	Y	2	29	32	22	25	25
Selenium	AN8a	mg/kg	Y	Y	1	<1	<1	<1	<1	<1
Zinc	AN8b	mg/kg	Y	Y	2	125	77	121	69	50
Sample Prep(C)										
EMR	EMR	%	N	N/A	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
% Stones	Stones	% w/w	N	N/A	0.1	23.4	9.4	16.6	<0.1	9.3
Moisture Content @ <30°C	AN1	% w/w	Y	N/A	0.1	14.1	15.4	15.6	19.2	15.7
Sample Description	MCERTS ver4.		N	N/A		5A	5AD	4A	5D	6AD
Misc										
pH	AN5a	Units	Y	Y	0.1	8.70	9.10	8.32	8.02	8.54
pH leachable	AN5c	Units	Y	N	0.1	8.29	8.31	8.27	8.28	8.35
Sulphate (total)	AN49	% w/w	Y	Y	0.02	0.07	0.09	0.08	0.03	0.05
Sulphate (water soluble)	CTP 29	g/l	Y	Y	0.01	0.06	0.09	0.08	<0.01	0.04
Sulphate leachable	AN50k	mg/l	Y	N	0.1	27.0	7.1	7.5	2.6	13.9
Sulphide _M	AN45b	mg/kg	N	N	2	<2	<2	<2	2	<2
Sulphide leachable	AN45h	mg/l	Y	N	0.1	<0.10	<0.10	<0.10	<0.10	<0.10
Cyanide leachable	AN45f	mg/l	Y	N	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cyanide (total) _M	AN45a	mg/kg	Y	Y	1	<1	<1	<1	<1	<1
Phenols (screen) _M	AN45a	mg/kg	Y	Y	1	<1	<1	<1	<1	<1
Organic Matter	AN48b	%	N	N	0.1	2.04	2.01	2.71	1.89	1.43
DOC (leachable)	TOC1b	mg/l	N	N	1	3.73	4.84	7.86	9.18	5.39
Chromium (VI)	AN7	mg/kg	Y	N	1	<1	<1	<1	<1	<1



Test Certificate

Client: Sutcliffe
18-20 Harrington Street, Liverpool, L2 9QA

Site: Langholme Heights - Ref 27601

Date Tested: 30/11/15

Date Reported: 4 December, 2015

Date Received: 27 November, 2015

Sample Type: Solid

Certificate No: 15/5973/G/S/C1

File No: 15/5973/G/S

Client Ref: No order supplied

Lab sample ref:	C227315	C227316	C227317	C227318	C227319
Client sample ref:	WS1 ES1	WS2 ES1	WS3 ES1	WS4 ES1	TP2 ES1 0.20-
	0.20-0.50m	0.20-0.50m	0.20-0.50m	0.20-0.50m	0.50m
Date sampled:	25/11/15	25/11/15	25/11/15	25/11/15	25/11/15
Sample matrix:	S	S	S	S	S

Determinand	Method	Units	ISO17025	MCERTS	LOD					
Misc										
Chromium (VI) leachable	HACH 4b	mg/l	N	N	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Elemental Sulphur _M	SOP11	mg/kg	Y	Y	20	<20	<20	<20	<20	<20
Asbestos	ASB001	N/A	Y	N/A		NAD	NAD	NAD	NAD	NAD
Elemental sulphur (leach)	SOP11a	mg/l	N	N/A	0.1	<0.2	<0.2	<0.2	<0.2	<0.2
MTBE _M	SOP01a	µg/kg	N	N	10	<10	<10	<10	<10	<10
BTEX										
Benzene _M	SOP01 U	µg/kg	Y	N	10	<10	<10	<10	<10	<10
Toluene _M	SOP01 U	µg/kg	Y	N	10	<10	<10	<10	<10	<10
Ethylbenzene _M	SOP01 M	µg/kg	Y	Y	10	<10	<10	<10	<10	<10
m,p-xylene _M	SOP01 M	µg/kg	Y	Y	10	<10	<10	<10	<10	<10
o-Xylene _M	SOP01 M	µg/kg	Y	Y	10	<10	<10	<10	<10	<10
PAH (USEPA16)										
Acenaphthene _M	GCM501	mg/kg	Y	Y	0.1	0.3	<0.1	<0.1	<0.1	0.1
Acenaphthylene _M	GCM501a	mg/kg	Y	Y	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene _M	GCM501	mg/kg	Y	Y	0.1	0.6	0.2	<0.1	<0.1	0.2
Benz(a)anthracene _M	GCM501	mg/kg	Y	Y	0.1	1.6	0.7	0.4	0.2	0.7
Benzo(a)pyrene _M	GCM501	mg/kg	Y	Y	0.1	2.2	0.7	0.4	0.4	0.7
Benzo(b)fluoranthene _M	GCM501	mg/kg	Y	Y	0.1	2.2	0.7	0.4	0.5	0.7
Benzo(ghi)perylene _M	GCM501	mg/kg	Y	Y	0.1	1.5	0.5	0.4	0.4	0.5
Benzo(k)fluoranthene _M	GCM501	mg/kg	Y	Y	0.1	1.2	0.4	0.2	0.2	0.4
Chrysene _M	GCM501	mg/kg	Y	Y	0.1	1.9	0.7	0.4	0.4	0.7
Dibenzo(a,h)anthracene _M	GCM501	mg/kg	Y	Y	0.1	0.2	<0.1	<0.1	<0.1	<0.1
Fluoranthene _M	GCM501	mg/kg	Y	Y	0.1	3.4	1.4	0.6	0.5	1.4
Fluorene _M	GCM501	mg/kg	Y	Y	0.1	0.2	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-cd)pyrene _M	GCM501a	mg/kg	Y	Y	0.1	1.4	0.4	0.2	0.2	0.4
Naphthalene (PAH) _M	GCM501	mg/kg	Y	Y	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene _M	GCM501	mg/kg	Y	Y	0.1	2.3	0.8	0.4	0.2	0.9
Pyrene _M	GCM501	mg/kg	Y	Y	0.1	3.5	1.3	0.6	0.5	1.3
PAH (USEPA16) Total _M	GCM501	mg/kg	Y	Y	0.1	22.6	7.7	3.8	3.6	8.2
PAH(USEPA16) leachable										
Naphthalene leachable	GCM502	µg/l	Y	N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Acenaphthylene leachable	GCM502	µg/l	Y	N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Acenaphthene leachable	GCM502	µg/l	Y	N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fluorene leachable	GCM502	µg/l	Y	N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Anthracene leachable	GCM502	µg/l	Y	N	0.02	<0.02	0.02	<0.02	<0.02	<0.02
Phenanthrene leachable	GCM502	µg/l	Y	N	0.02	0.04	0.05	0.02	<0.02	<0.02
Fluoranthene leachable	GCM502	µg/l	Y	N	0.02	0.02	0.08	0.02	<0.02	<0.02
Pyrene leachable	GCM502	µg/l	Y	N	0.02	0.02	0.06	<0.02	<0.02	<0.02
Chrysene leachable	GCM502	µg/l	Y	N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(b)fluoranthene leachable	GCM502	µg/l	Y	N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(k)fluoranthene leachable	GCM502	µg/l	Y	N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(a)pyrene leachable	GCM502	µg/l	Y	N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Indeno(1,2,3-cd)pyrene leachable	GCM502	µg/l	Y	N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Dibenzo(a,h)anthracene leachable	GCM502	µg/l	Y	N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(ghi)perylene leachable	GCM502	µg/l	Y	N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(a)anthracene leachable	GCM502	µg/l	Y	N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02



Test Certificate

Client: Sutcliffe
18-20 Harrington Street, Liverpool, L2 9QA

Site: Langholme Heights - Ref 27601

Date Tested: 30/11/15

Date Reported: 4 December, 2015

Date Received: 27 November, 2015

Sample Type: Solid

Certificate No: 15/5973/G/S/C1

File No: 15/5973/G/S

Client Ref: No order supplied

Lab sample ref:	C227315	C227316	C227317	C227318	C227319
Client sample ref:	WS1 ES1 0.20-0.50m	WS2 ES1 0.20-0.50m	WS3 ES1 0.20-0.50m	WS4 ES1 0.20-0.50m	TP2 ES1 0.20- 0.50m
Date sampled:	25/11/15	25/11/15	25/11/15	25/11/15	25/11/15
Sample matrix:	S	S	S	S	S

Determinand	Method	Units	ISO17025	MCERTS	LOD					
Phenols(Speciated) Leachate										
Phenol leachable	SOP04d	µg/l	Y	N	1	<1	<1	<1	<1	<1
2-Chlorophenol leachable	SOP04d	µg/l	Y	N	1	<1	<1	<1	<1	<1
2-Methylphenol leachable	SOP04d	µg/l	Y	N	1	<1	<1	<1	<1	<1
4-Methylphenol leachable	SOP04d	µg/l	Y	N	1	<1	<1	<1	<1	<1
2-Nitrophenol leachable	SOP04d	µg/l	Y	N	1	<1	<1	<1	<1	<1
2,4-Dimethylphenol leachable	SOP04d	µg/l	Y	N	1	<1	<1	<1	<1	<1
2,4-Dichlorophenol leachable	SOP04d	µg/l	Y	N	1	<1	<1	<1	<1	<1
4-Chloro-3-Methylphenol leachable	SOP04d	µg/l	Y	N	1	<1	<1	<1	<1	<1
4-Nitrophenol leachable	SOP04f	µg/l	Y	N	10	<10	<10	<10	<10	<10
2-methyl-4,6-dinitrophenol leachable	SOP04f	µg/l	Y	N	10	<10	<10	<10	<10	<10
Pentachlorophenol leachable	SOP04e	µg/l	Y	N	5	<5	<5	<5	<5	<5
2,4,5-Trichlorophenol leachable	SOP04d	µg/l	Y	N	1	<1	<1	<1	<1	<1
TPH Banded(Alk/Aro) (C6-C44)										
>C7-C8 Aromatic _M	SOP01a	mg/kg	N	N	1	<1	<1	<1	<1	<1
>C6-C8 Aliphatic _M	SOP01a	mg/kg	N	N	1	<1	<1	<1	<1	<1
C5-C6 Aliphatic _M	SOP01a	mg/kg	N	N	1	<1	<1	<1	<1	<1
C5-C7 Aromatic _M	SOP01a	mg/kg	N	N	1	<1	<1	<1	<1	<1
>C8-C10 Aliphatic _M	AN51a	mg/kg	N	N	10	<10	<10	<10	<10	<10
>C8-C10 Aromatic _M	AN51a	mg/kg	N	N	10	<10	<10	<10	<10	<10
>C10-C12 Aliphatic _M	AN51a	mg/kg	N	N	10	<10	<10	<10	<10	<10
>C10-C12 Aromatic _M	AN51a	mg/kg	N	N	10	<10	<10	<10	<10	<10
>C12-C16 Aliphatic _M	AN51a	mg/kg	N	N	10	<10	<10	<10	<10	<10
>C12-C16 Aromatic _M	AN51a	mg/kg	N	N	10	<10	<10	<10	<10	<10
>C16-C21 Aliphatic _M	AN51a	mg/kg	N	N	10	19	<10	<10	<10	<10
>C16-C21 Aromatic _M	AN51a	mg/kg	N	N	10	<10	<10	<10	<10	<10
>C21-C36 Aliphatic _M	AN51a	mg/kg	N	N	10	116	<10	<10	<10	36
>C21-C36 Aromatic _M	AN51a	mg/kg	N	N	10	70	<10	<10	<10	90
>C36-C44 Aliphatic _M	AN51a	mg/kg	N	N	10	33	<10	<10	<10	24
>C36-C44 Aromatic _M	AN51a	mg/kg	N	N	10	84	12	<10	<10	112
TPH Speciated Leachable										
GRO (leachable)	AN34b	mg/l	Y	N	0.1	<0.10	<0.10	<0.10	<0.10	<0.10
DRO (leachable)	AN34b	mg/l	Y	N	0.1	<0.10	<0.10	<0.10	<0.10	<0.10
MRO (leachable)	AN34b	mg/l	Y	N	0.1	<0.10	<0.10	<0.10	<0.10	<0.10

Notes

1. All analyses performed on the sample dried at <30°C, except analyses suffixed with 'M'.
2. Analyses suffixed 'M' were performed on the sample as received and corrected for '% moisture at <30°C' where applicable.
3. All results are expressed as dry weight.
4. MCERTS accreditation applicable to Sample Matrix 'S' only.
5. Natural stones (pebbles, gravels etc.) which do not pass a 4mm sieve are excluded from dried analyses.
6. Tests marked * indicate subcontracted analyses.
7. The laboratory has tested the material/items supplied by the client as sampled in accordance with the client's own requirements.
8. ^Sample Description key: 1. - Sand, 2. Loam, 3. Clay, 4. Sand/loam mix, 5. Sand/clay mix, 6. Clay/loam mix, 7. Other.
suffixed with: A - Stones, B - Construction rubble, C - Visible Hydrocarbons, D - Vegetation, E - Glass/metal, F - Strong odour, G - Other.
9. Leachate preparation is not included in our UKAS accreditation.
10. Dates of testing for all parameters are available upon request.
11. EMR denotes Extraneous material.
12. Sampling location details and sample information were supplied with the sample.
13. Bulk Analysis carried out in accordance with DIHM ASB/01 which is based on Health & Safety Executive procedure
Appendix 2: Asbestos in Bulk Materials: Sampling and identification by polarised light microscopy (PLM) set out in HSG248.
14. Asbestos material identification is based on visual examination only. Comments are not covered by UKAS accreditation.
15. NAD denotes - 'No Asbestos Detected'.
16. *Deviating samples* : Deviating samples can be defined as those which are not (correctly) cared for. As a result, deviating samples may jeopardise the validity of the reported test result. Where a deviation has been found in relation to the sample(s) submitted for testing, the test result may be compromised. Reasons for deviating samples are denoted by means of a number 1, 2, 3, 4, 5A, 5B, 6 or 7 under the analyte 'Deviation(s)'. Explanation of this number coding as follows: 1. Sample not submitted in an appropriate container(organic testing), 2. Sample not submitted in an appropriate container(inorganic testing), 3. Sample not submitted in an appropriate container(all testing), 4. Sample lacks the date and time of sampling, 5A – Sample stability time exceeded prior to commencement of testing/receipt of sample, 5B – Sample stability time exceeded during testing, 6. Inappropriate storage/transit conditions, and 7. Other (please contact the laboratory for further information).

Signed for, and on behalf of Exova (UK) Ltd.

Prepared by:

C McLaughlin
Administrator

Approved by:

J McEleny
Laboratory Manager



The contents of this document are governed by the terms and conditions overleaf.

Registered Office: Exova (UK) Ltd. Lochend Industrial Estate, Newbridge, Midlothian, EH28 8PL United Kingdom. Reg No. SC 70429

Appendix E - Ground Gas & Groundwater Monitoring Data

	SUTCLIFFE INVESTIGATIONS TEL: 0151 227 3155 FAX: 0151 227 3156					GAS MEASUREMENTS AND WATER LEVELS		Sheet No.: 1 of 1		
								Atmospheric Pressure: 1012mb		
								Weather: Cloudy/Drizzle		
								Pressure Trend: Steady		
CLIENT: LHT					SITE: Langholme Heights					
Date of Fieldwork: 08.12.15					Logged By: CB		Job No.: 27601LG			
B/H REF	CH ₄		CO ₂	O ₂	Relative Pressure	Flow Rate	P.I.D	Base of Borehole	Water Level	Reduced Water Level
	%LEL	%by vol	%by vol	%by vol	(mb)	(l/h)		(mbgl)	(mbgl)	(m) A.O.D
WS1		0.0	0.4	20.6	0.0	0.0	-	3.00	1.07	-
		0.0	0.3	19.8						
		0.0	0.2	20.4						
		0.0	0.1	20.8						
WS2		0.0	1.9	17.3	0.0	0.0	-	3.00	0.73	-
		0.0	1.9	15.2						
		0.0	2.0	14.8						
		0.0	2.0	14.6						
WS3		0.0	0.4	20.0	0.0	0.0	-	3.00	-	-
		0.0	0.7	17.5						
		0.0	0.8	16.9						
		0.0	0.8	16.4						
WS4		0.0	0.2	21.1	0.0	0.0	-	3.00	FULL	-
		0.0	0.2	21.1						
		0.0	0.2	21.1						
		0.0	0.2	21.1						
COMMENTS: Bung stuck in WS3.										
INSTRUMENT USED:			ACCURACY OF INSTRUMENT (% by volume)		CH₄ ± 0.5% @ 5% ± 1.0% @15% ±3.0% @>15%		CO₂ ± 0.5% @ 5% ± 1.0% @15% ±3.0% @>15%		O₂ ± 1.0%	

A = Accumulated Type Sample SS = Steady State Type Sample P = Peak Type Sample l/h = Litres per hour

%LEL = Lower Explosive Limit (for CH₄ in air 100% = 5% by volume) mb = Millibar mbgl = Metres Below Ground Level

	SUTCLIFFE INVESTIGATIONS TEL: 0151 227 3155 FAX: 0151 227 3156					GAS MEASUREMENTS AND WATER LEVELS		Sheet No.: 1 of 1		
								Atmospheric Pressure: 1002mb		
								Weather: Raining		
			Pressure Trend: Steady							
CLIENT: LHT					SITE: Langholme Heights					
Date of Fieldwork: 21.12.15					Logged By: CB		Job No.: 27601LG			
B/H REF	CH ₄		CO ₂	O ₂	Relative Pressure	Flow Rate	P.I.D	Base of Borehole	Water Level	Reduced Water Level
	%LEL	%by vol	%by vol	%by vol	(mb)	(l/h)		(mbgl)	(mbgl)	(m) A.O.D
WS1		0.0	0.2	20.8	0.0	0.0	-	3.00	1.02	-
		0.0	0.2	20.9						
		0.0	0.1	21.0						
		0.0	0.1	21.1						
WS2		0.0	1.4	18.0	0.0	0.0	-	3.00	0.71	-
		0.0	1.5	18.2						
		0.0	1.6	18.3						
		0.0	1.7	18.3						
WS3		0.0	0.8	19.3	0.0	0.0	-	3.00	-	-
		0.0	0.8	18.7						
		0.0	0.8	18.5						
		0.0	0.8	18.3						
WS4		0.0	0.1	21.2	0.0	0.0	-	3.00	0.23	-
		0.0	0.1	21.2						
		0.0	0.1	21.3						
		0.0	0.1	21.3						
COMMENTS: Bung stuck in WS3.										
INSTRUMENT USED:			ACCURACY OF INSTRUMENT (% by volume)		CH₄ ± 0.5% @ 5% ± 1.0% @15% ±3.0% @>15%		CO₂ ± 0.5% @ 5% ± 1.0% @15% ±3.0% @>15%		O₂ ± 1.0%	

A = Accumulated Type Sample SS = Steady State Type Sample P = Peak Type Sample l/h = Litres per hour

%LEL = Lower Explosive Limit (for CH₄ in air 100% = 5% by volume) mb = Millibar mbgl = Metres Below Ground Level

	SUTCLIFFE INVESTIGATIONS TEL: 0151 227 3155 FAX: 0151 227 3156					GAS MEASUREMENTS AND WATER LEVELS		Sheet No.: 1 of 1		
								Atmospheric Pressure: 984mb		
								Weather: Cloudy		
	CLIENT: LHT					SITE: Langholme Heights				
Date of Fieldwork: 06.01.16					Logged By: CB		Job No.: 27601LG			
B/H REF	CH ₄		CO ₂	O ₂	Relative Pressure	Flow Rate	P.I.D	Base of Borehole	Water Level	Reduced Water Level
	%LEL	%by vol	%by vol	%by vol	(mb)	(l/h)		(mbgl)	(mbgl)	(m) A.O.D
WS1		0.1	0.1	21.4	0.0	0.0	-	3.00	0.31	-
		0.1	0.1	21.4						
		0.1	0.1	21.4						
		0.1	0.1	21.4						
WS2		0.1	1.5	19.1	0.0	0.0	-	3.00	0.79	-
		0.2	1.6	18.8						
		0.1	1.7	18.7						
		0.1	1.7	18.9						
WS3		0.1	0.8	19.1	0.0	0.0	-	3.00	-	-
		0.2	0.8	19.1						
		0.1	0.8	19.1						
		0.1	0.8	19.1						
WS4		0.1	0.2	21.4	0.0	0.0	-	3.00	0.31	-
		0.1	0.2	21.4						
		0.1	0.1	21.4						
		0.1	0.1	21.4						
COMMENTS: Bung stuck in WS3.										
INSTRUMENT USED:			ACCURACY OF INSTRUMENT (% by volume)		CH₄ ± 0.5% @ 5% ± 1.0% @15% ±3.0% @>15%		CO₂ ± 0.5% @ 5% ± 1.0% @15% ±3.0% @>15%		O₂ ± 1.0%	

A = Accumulated Type Sample SS = Steady State Type Sample P = Peak Type Sample l/h = Litres per hour

%LEL = Lower Explosive Limit (for CH₄ in air 100% = 5% by volume) mb = Millibar mbgl = Metres Below Ground Level

	SUTCLIFFE INVESTIGATIONS TEL: 0151 227 3155 FAX: 0151 227 3156					GAS MEASUREMENTS AND WATER LEVELS		Sheet No.: 1 of 1		
								Atmospheric Pressure: 1012mb		
								Weather: Overcast/Drizzle		
			Pressure Trend: Steady							
CLIENT: LHT					SITE: Langholme Heights					
Date of Fieldwork: 21.01.16					Logged By: CB		Job No.: 27601LG			
B/H REF	CH ₄		CO ₂	O ₂	Relative Pressure	Flow Rate	P.I.D	Base of Borehole	Water Level	Reduced Water Level
	%LEL	%by vol	%by vol	%by vol	(mb)	(l/h)		(mbgl)	(mbgl)	(m) A.O.D
WS1		0.1	0.4	15.7	0.0	+2.1	-	3.00	1.02	-
		0.1	0.4	16.5						
		0.1	0.4	17.4						
		0.1	0.4	18.0						
WS2		0.1	2.3	10.2	0.0	0.0	-	3.00	1.12	-
		0.1	2.3	10.1						
		0.1	2.3	10.2						
		0.1	2.3	10.2						
WS3		0.1	2.2	9.3	0.0	0.0	-	3.00	-	-
		0.1	2.2	7.1						
		0.1	2.3	6.6						
		0.1	2.3	6.3						
WS4		-	-	-	-	-	-	3.00	FULL	-
COMMENTS: Bung stuck in WS3.										
INSTRUMENT USED:			ACCURACY OF INSTRUMENT (% by volume)		CH₄ ± 0.5% @ 5% ± 1.0% @15% ±3.0% @>15%		CO₂ ± 0.5% @ 5% ± 1.0% @15% ±3.0% @>15%		O₂ ± 1.0%	

A = Accumulated Type Sample SS = Steady State Type Sample P = Peak Type Sample l/h = Litres per hour

%LEL = Lower Explosive Limit (for CH₄ in air 100% = 5% by volume) mb = Millibar mbgl = Metres Below Ground Level

	SUTCLIFFE INVESTIGATIONS TEL: 0151 227 3155 FAX: 0151 227 3156					GAS MEASUREMENTS AND WATER LEVELS		Sheet No.: 1 of 1	
								Atmospheric Pressure: 993mb	
								Weather: Overcast	
			CLIENT: LHT					SITE: Langholme Heights	
		Date of Fieldwork: 12.02.16					Logged By: CB		Job No.: 27601LG

B/H REF	CH ₄		CO ₂	O ₂	Relative Pressure	Flow Rate	P.I.D	Base of Borehole	Water Level	Reduced Water Level
	%LEL	%by vol	%by vol	%by vol	(mb)	(l/h)		(mbgl)	(mbgl)	(m) A.O.D
WS1		0.1	0.3	18.0	0.0	+0.2	-	3.00	0.99	-
		0.1	0.3	18.5						
		0.1	0.2	18.8						
		0.1	0.2	18.9						
WS2		0.1	2.0	10.8	0.0	0.0	-	3.00	1.12	-
		0.1	2.2	10.9						
		0.1	2.4	11.0						
		0.1	2.5	11.0						
WS3		0.1	3.0	8.8	0.0	0.0	-	3.00	-	-
		0.1	3.1	6.0						
		0.1	3.2	5.7						
		0.1	3.3	5.5						
WS4		-	-	-	-	-	-	3.00	FULL	-

COMMENTS: Bung stuck in WS3.

INSTRUMENT USED:	ACCURACY OF INSTRUMENT (% by volume)	CH₄ ± 0.5% @ 5% ± 1.0% @ 15% ± 3.0% @ >15%	CO₂ ± 0.5% @ 5% ± 1.0% @ 15% ± 3.0% @ >15%	O₂ ± 1.0%
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A = Accumulated Type Sample SS = Steady State Type Sample P = Peak Type Sample l/h = Litres per hour

%LEL = Lower Explosive Limit (for CH₄ in air 100% = 5% by volume) mb = Millibar mbgl = Metres Below Ground Level

	SUTCLIFFE INVESTIGATIONS TEL: 0151 227 3155 FAX: 0151 227 3156					GAS MEASUREMENTS AND WATER LEVELS		Sheet No.: 1 of 1	
								Atmospheric Pressure: 1027mb	
								Weather: Overcast	
			CLIENT: LHT					SITE: Langholme Heights	
		Date of Fieldwork: 16.02.16					Logged By: CB		Job No.: 27601LG

B/H REF	CH ₄		CO ₂	O ₂	Relative Pressure	Flow Rate	P.I.D	Base of Borehole	Water Level	Reduced Water Level
	%LEL	%by vol	%by vol	%by vol	(mb)	(l/h)		(mbgl)	(mbgl)	(m) A.O.D
WS1		0.1	0.4	18.8	0.0	0.0	-	3.00	0.92	-
		0.1	0.3	19.0						
		0.1	0.2	19.2						
		0.1	0.1	19.3						
WS2		0.1	2.1	12.4	0.0	0.0	-	3.00	1.16	-
		0.1	2.1	12.6						
		0.1	2.1	12.7						
		0.1	2.1	12.8						
WS3		0.1	2.5	10.6	0.0	0.0	-	3.00	-	-
		0.1	2.6	7.0						
		0.1	2.7	6.0						
		0.1	2.7	5.8						
WS4		-	-	-	-	-	-	3.00	FULL	-

COMMENTS: Bung stuck in WS3.

INSTRUMENT USED:	ACCURACY OF INSTRUMENT (% by volume)	CH₄ ± 0.5% @ 5% ± 1.0% @ 15% ± 3.0% @ >15%	CO₂ ± 0.5% @ 5% ± 1.0% @ 15% ± 3.0% @ >15%	O₂ ± 1.0%
-------------------------	---	---	---	--------------------------------

A = Accumulated Type Sample SS = Steady State Type Sample P = Peak Type Sample l/h = Litres per hour

%LEL = Lower Explosive Limit (for CH₄ in air 100% = 5% by volume) mb = Millibar mbgl = Metres Below Ground Level

Appendix F – Geotechnical Laboratory Cerificates

SUMMARY OF LABORATORY SOIL TEST RESULTS

BH / TP / WS Number	Sample Type	Depth From (m)	Depth To (m)	Moisture Content (%)	Bulk Density (Mg/m ³)	Dry Density (Mg/m ³)	Shear Strength (kN/m ²)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Passing 0.425mm (%)	Soil Classification	UKAS accredited test (Y/N)	Description / Test Method Samples described in accordance with BS EN ISO 14688-2 2004
WS1	WS	1.70	1.90	14	-	-	184	30	13	17	90	CL	Y	Brown slightly sand slightly gravelly silty CLAY. (BS1377Pt2:3.2,4.4,5,Pt7:8)
WS2	WS	1.00	2.00	19	-	-	-	-	-	-	91	NP	Y	Brown slightly silty slightly gravelly clayey fine to medium grained SAND. Gravel is fine to coarse angular brick. With occasional pockets of brown clay and peat. (BS1377Pt2:3.2,4.4,5)
WS3	WS	1.60	1.80	17	-	-	141	31	13	18	98	CL	Y	Brown slightly sand slightly gravelly silty CLAY. (BS1377Pt2:3.2,4.4,5,Pt7:8)
WS4	WS	2.50	3.00	18	-	-	-	31	13	18	95	CL	Y	Brown slightly sand slightly gravelly silty CLAY. (BS1377Pt2:3.2,4.4,5)

SITE: LANGHOLME HEIGHTS / CCG-C-15-8739
CLIENT: SUTCLIFFE

DATE: 21.12.15
SHEET: 1 of 1

Key:- BD = Bulk Disturbed; SD = Small Disturbed; U100 = Undisturbed 100mm; WS = Window Sample

CL = Low Plasticity; CI = Intermediate; CH = High; CV = Very high; CE = Extremely high; NP = Non-plastic

(* Denotes Hand Shear Vane test result)

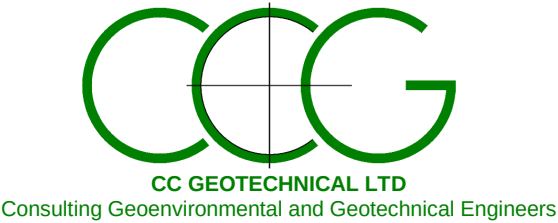
Sample description not accredited by UKAS



RES SHEET.xls

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LABORATORY REPORT

CONTRACT NUMBER: CCG-C-21-12733

CONTRACT TITLE: LANGHOLME, LIVERPOOL

CLIENT: SUTCLIFFE
18-20 Harrington Street, Liverpool L2 9QA

DATE RECEIVED: 10/11/21
DATE COMMENCED: 10/11/21
DATE COMPLETED: 18/11/21
REPORT DATE: 18/11/21

Test Description	Qty
Determination of Liquid & Plastic Limits BS 1377-2:1990 (a)	4
Determination of Moisture Content BS 1377-2:1990 (a)	2
Unconsolidated Undrained Triaxial Compression BS1377-7:1990 (a)	2

Notes: Observations and interpretations are not accredited by UKAS
All testing undertaken at laboratory permanent facilities
denotes non-accredited test
a denotes UKAS accredited test
s denotes test undertaken by approved subcontractor
Test results only relate to the samples tested
Sample and sample information supplied by client

This report is issued in accordance with the requirements of the United Kingdom Accreditation Services and EN ISO/IEC 17025:2017. The results reported herein relate only to the material supplied to the laboratory. This report shall not be reproduced except in full, without the prior written approval of the laboratory.
Approved Signatories: Chris Bolan (Managing Director) – Daniel Kerfoot (Laboratory Manager)

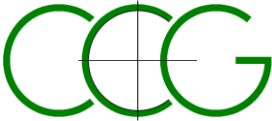
SUMMARY OF LABORATORY SOIL TEST RESULTS

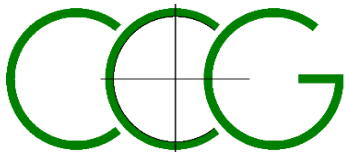
BH / TP / WS Number	Sample Type	Depth From (m)	Depth To (m)	Moisture Content (%)	Bulk Density (Mg/m³)	Dry Density (Mg/m³)	Shear Strength (kN/m²)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Passing 0.425mm (%)	Soil Classification	UKAS accredited test (Y/N)	Description / Test Method Samples described in accordance with BS EN ISO 14688-2 2004
BH101	U	5.00	5.45	15	2.17	1.89	78	33	17	16	91	CL	Y	Brown slightly sandy slightly gravelly silty CLAY of high undrained shear strength. (BS1377Pt2:3.2,4.4,5,Pt7:8)
BH102	U	5.00	5.45	18	-	-	90*	34	17	17	94	CL	Y	Brown slightly sandy slightly gravelly silty CLAY. (BS1377Pt2:3.2,4.4,5)
BH103	U	5.00	5.45	16	2.19	1.89	54	32	16	16	86	CL	Y	Brown slightly sandy slightly gravelly silty CLAY of medium undrained shear strength. (BS1377Pt2:3.2,4.4,5,Pt7:8)
BH103	B	15.00	15.45	16	-	-	110*	36	17	19	90	CI	Y	Brown slightly sandy slightly gravelly silty CLAY. (BS1377Pt2:3.2,4.4,5)

SITE: LANGHOLME, LIVERPOOL (CCG-C-21-12733)
CLIENT: SUTCLIFFE

DATE: 18.11.21

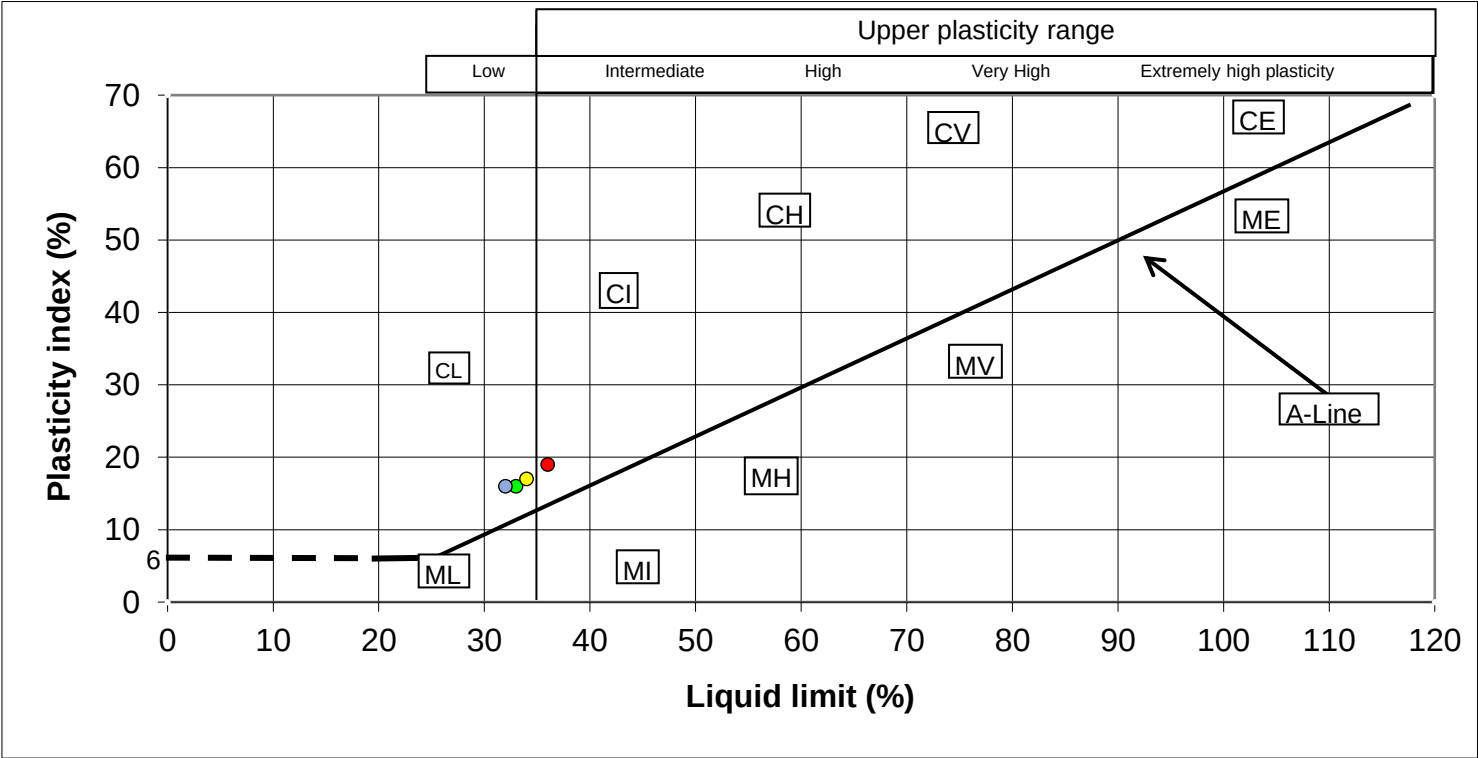
Key:- BD = Bulk Disturbed; SD = Small Disturbed; U100 = Undisturbed 100mm; WS = Window Sample
CL = Low Plasticity; CI = Intermediate; CH = High; CV = Very high; CE = Extremely high; NP = Non-plastic
(* Denotes Hand Shear Vane test result)
Sample description not accredited by UKAS





ATTERBERG TEST RESULT SHEET
BS 1377:Part 2:1990:cl 4.4,5

SILT (M-SOIL), M plots below A-Line , CLAY,C, plots above A-Line, M and C may be combined as FINE SOIL, F.



BH	Sample Depth	Liquid limit	Plasticity index
BH101	5.00	33.0	16.0
BH102	5.00	34.0	17.0
BH103	5.00	32.0	16.0
BH103	15.00	36.0	19.0



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APPROVED BY DK

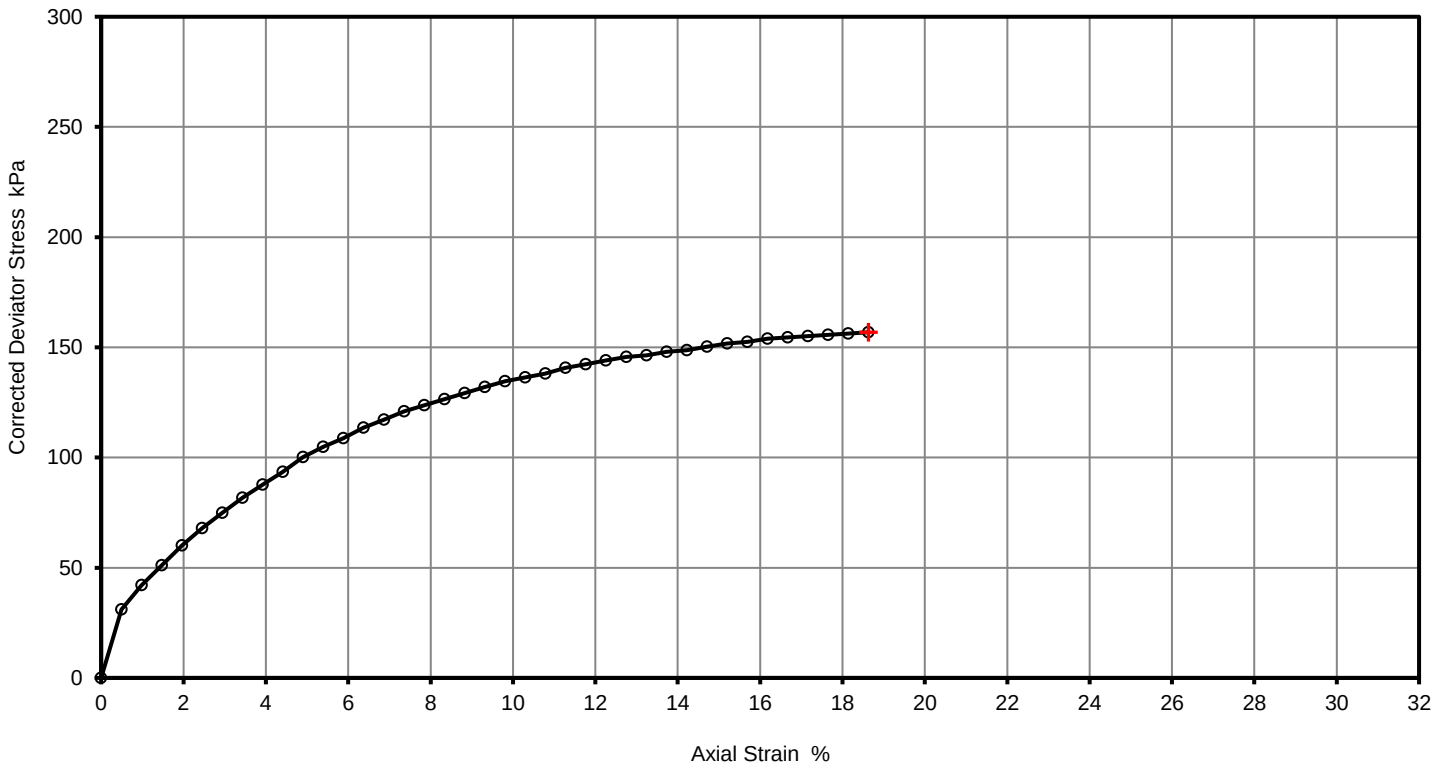
CLIENT: SUTCLIFFE SITE: LANGHOLME, LIVERPOOL (CCG-C-21-12733)

 CC Geotechnical Ltd Tel: 0151 545 2750 e: lab@ccgeotechnical.com	Unconsolidated Undrained Triaxial Compression Test without measurement of pore pressure - single specimen			Job Ref	CCG-C-21-12733
				Borehole/Pit No.	BH101
Site Name	LANGHOLME, LIVERPOOL			Sample No.	1
Soil Description				Depth	5.00
Specimen Reference		Specimen Depth	m	Sample Type	U
Specimen Description	Brown slightly sandy slightly gravelly silty CLAY			Date of test	10/11/2021
Test Method	BS1377 : Part 7 : 1990, clause 8, single specimen				



Test Number	1	
Length	203.9	mm
Diameter	102.2	mm
Bulk Density	2.17	Mg/m3
Moisture Content	14.9	%
Dry Density	1.89	Mg/m3
Rate of Strain	2.0	%/min
Cell Pressure	100	kPa
At failure	18.6	%
Axial Strain	157	kPa
Deviator Stress, ($\sigma_1 - \sigma_3$)f	78	kPa
Undrained Shear Strength, cu		$\frac{1}{2}(\sigma_1 - \sigma_3)$ f
Mode of Failure	Plastic	

Deviator Stress v Axial Strain



Remarks

Approved

DanielKerfoot

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Fig. No.

1

Sheet

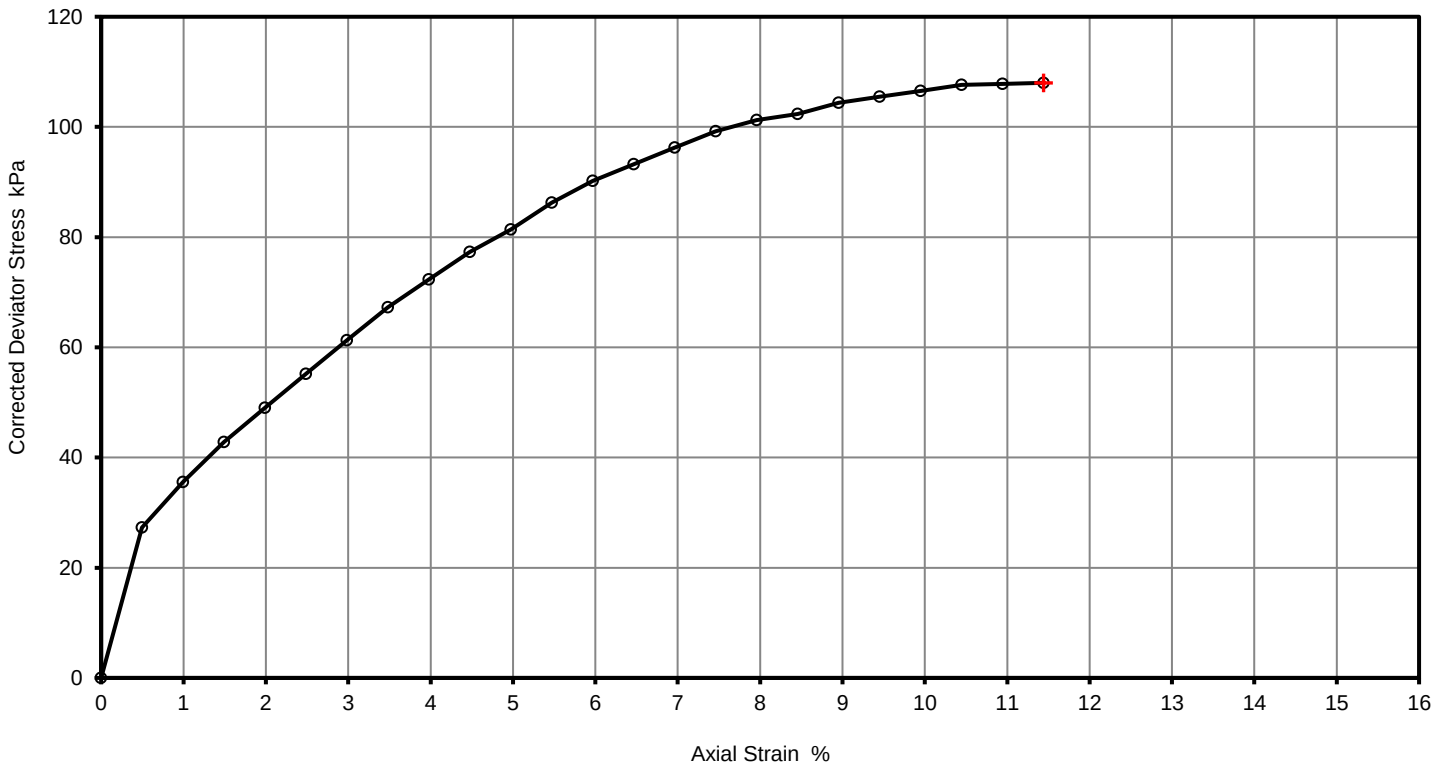
1

 CC Geotechnical Ltd Tel: 0151 545 2750 e: lab@ccgeotechnical.com	Unconsolidated Undrained Triaxial Compression Test without measurement of pore pressure - single specimen		Job Ref	CCG-C-21-12733
			Borehole/Pit No.	BH103
Site Name	LANGHOLME, LIVERPOOL		Sample No.	1
Soil Description			Depth	5.00
Specimen Reference		Specimen Depth	Sample Type	U
Specimen Description	Brown slightly sandy slightly gravelly silty CLAY		Date of test	10/11/2021
Test Method	BS1377 : Part 7 : 1990, clause 8, single specimen			



Test Number	1	
Length	201.0	mm
Diameter	102.1	mm
Bulk Density	2.19	Mg/m3
Moisture Content	15.6	%
Dry Density	1.89	Mg/m3
Rate of Strain	2.0	%/min
Cell Pressure	100	kPa
At failure	11.4	%
Axial Strain	108	kPa
Deviator Stress, ($\sigma_1 - \sigma_3$)f	54	kPa $\frac{1}{2}(\sigma_1 - \sigma_3)$ f
Undrained Shear Strength, cu	Brittle	
Mode of Failure		

Deviator Stress v Axial Strain



Remarks

Approved

DanielKerfoot

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Fig. No.

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Sheet

2

Appendix G - Soil Screening Values



Job Name:	Langholme Heights
Job Number:	27601LG

Sutcliffe			ATKINS REVISED 31/03/11, CATEGORY 4 - APRIL 2014, LQM JAN 2015												
RESIDENTIAL WITH PLANT UPTAKE															
Contaminant	Units	Category 4 Screening Values (6%)	SGV	Atkins Atrisk 1% SOM	Additional Values for 1% SOM (mg/kg) See notes	Atkins Atrisk 6% SOM	Additional Values for 6% SOM (mg/kg) See notes	LQM			C227315 WS1 ES1 0.20-0.50m	C227316 WS2 ES1 0.20-0.50m	C227317 WS3 ES1 0.20-0.50m	C227318 WS4 ES1 0.20-0.50m	C227319 TP2 ES1 0.20-0.50m
								SOM 1%	SOM 2.5%	SOM 5%					
Arsenic (Total)	mg/kg	37	32	32		32		37			12	13	11	7	6
Boron (Soluble)	mg/kg							290			0.9	1	0.9	0.8	0.7
Cadmium (Total)	mg/kg	26	10	10		10		11			<1	<1	<1	<1	<1
Chromium III	mg/kg			12800		12800		910			22	22	22	27	25
Chromium VI	mg/kg	21		14.2		14.5		6			<1	<1	<1	<1	<1
Copper (Total)	mg/kg			3970		4020		2400			42	42	56	41	22
Lead (Total)	mg/kg	200		276		342					59	62	81	55	32
Mercury (Total)	mg/kg		170	170		170		40			<1	<1	<1	<1	<1
Nickel (Total)	mg/kg		130	130		130		180			29	32	22	25	25
Selenium (Total)	mg/kg		350	350		350		250			<1	<1	<1	<1	<1
Zinc (Total)	mg/kg			16900		17200		3700			125	77	121	69	50
Cyanide (Total)	mg/kg			34		34					<1	<1	<1	<1	<1
Phenols (Total)	mg/kg		420	162		420		280	550	1100	<1	<1	<1	<1	<1
Organic matter	%										2.04	2.01	2.71	1.89	1.43
Sulphate (Total) as SO3	%										0.07	0.09	0.08	0.03	0.05
Sulphate as Water Soluble	g/l										0.06	0.09	0.08	<0.01	0.04
Sulphide	mg/kg										<2	<2	<2	2	<2
pH	pH units										8.7	9.1	8.32	8.02	8.54
Sulphur (Elemental)	mg/kg										<20	<20	<20	<20	<20
Asbestos	mg/kg										NAD	NAD	NAD	NAD	NAD
>> TPH SUITE <<															
TPH (Total)															
Total Aliphatic															
>C5 to C6 aliphatic	mg/kg			30.1		259		42	78	160	<1	<1	<1	<1	<1
>C6 to C8 aliphatic	mg/kg			69.8		14700	769	100	230	530	<1	<1	<1	<1	<1
>C8 to C10 aliphatic	mg/kg			9.79		144		27	65	150	<10	<10	<10	<10	<10
>C10 to C12 aliphatic	mg/kg			1390	49.9	4140	297	130	330	760	<10	<10	<10	<10	<10
>C12 to C16 aliphatic	mg/kg			5100	21	5260	126	1100	2400	4300	<10	<10	<10	<10	<10
>C16 to C21 aliphatic	mg/kg			145000		145000		65000	92000	110000	19	<10	<10	<10	<10
>C21 to C36 aliphatic	mg/kg			145000		145000		65000	92000	110000	116	<10	<10	<10	36
>C36 to C44 aliphatic	mg/kg			145000		145000		65000	92000	110000	33	<10	<10	<10	24
Total Aromatic															
>C5 to C7 aromatic (Benzene)	mg/kg		0.33	0.0493		0.33		70	140	300	<1	<1	<1	<1	<1
>C7 to C8 aromatic (Toluene)	mg/kg			86.9		610		130	290	660	<1	<1	<1	<1	<1
>C8 to C10 aromatic	mg/kg			14.8		177		34	83	190	<10	<10	<10	<10	<10
>C10 to C12 aromatic	mg/kg			57.3		389		74	180	380	<10	<10	<10	<10	<10
>C12 to C16 aromatic	mg/kg			142		687		140	330	660	<10	<10	<10	<10	<10
>C16 to C21 aromatic	mg/kg			272		804		260	540	930	<10	<10	<10	<10	<10
>C21 to C36 aromatic	mg/kg			888		1220		1100	1500	1700	70	<10	<10	<10	90
>C36 to C44 aromatic	mg/kg			888		1220		1100	1500	1700	84	12	<10	<10	112
>> BTEX SUITE <<															
benzene	mg/kg	0.87	0.33	0.0493		0.33		0.87	0.17	0.37	<0.01	<0.01	<0.01	<0.01	<0.01
toluene	mg/kg		610	86.9		610		130	290	660	<0.01	<0.01	<0.01	<0.01	<0.01
ethylbenzene	mg/kg		350	38.2		350		47	110	260	<0.01	<0.01	<0.01	<0.01	<0.01
m,p Xylene	mg/kg		230	17.2		230		56	130	310	<0.01	<0.01	<0.01	<0.01	<0.01
o-Xylene	mg/kg		250	18.9		250		60	140	330	<0.01	<0.01	<0.01	<0.01	<0.01
>> PAH SUITE <<															
naphthalene	mg/kg			0.585		8.71		2.3	5.6	13	<0.1	<0.1	<0.1	<0.1	<0.1
acenaphthylene	mg/kg							170	420	920	<0.1	<0.1	<0.1	<0.1	<0.1
acenaphthene	mg/kg			588	157	2130	937	210	510	1100	0.3	<0.1	<0.1	<0.1	0.1
fluorene	mg/kg			615	125	1930	746	170	400	860	0.2	<0.1	<0.1	<0.1	<0.1
phenanthrene	mg/kg							95	220	440	2.3	0.8	0.4	0.2	0.9
anthracene	mg/kg			8270	3.48	18300	20.9	2400	5400	11000	0.6	0.2	<0.1	<0.1	0.2
fluoranthene	mg/kg			822	18.9	2160	113	280	560	890	3.4	1.4	0.6	0.5	1.4
pyrene	mg/kg			563	2.2	1550	13.2	620	1200	2000	3.5	1.3	0.6	0.5	1.3
benzo(a)anthracene	mg/kg			4.52	1.71	8.54		7.2	11	13	1.6	0.7	0.4	0.2	0.7
chrysene	mg/kg			585	0.44	927	2.64	15	22	27	1.9	0.7	0.4	0.4	0.7
benzo(b)fluoranthene	mg/kg			7.72	1.22	9.86	7.29	2.6	3.3	3.7	2.2	0.7	0.4	0.5	0.7
benzo(k)fluoranthene	mg/kg			84.4	0.686	100	4.12	77	93	100	1.2	0.4	0.2	0.2	0.4
benzo(a)pyrene	mg/kg	5		0.818		0.998		2.2	2.7	3	2.2	0.7	0.4	0.4	0.7
dibenzo(ah)anthracene	mg/kg			0.838	0.00393	1	0.0236	0.24	0.28	0.3	0.2	<0.1	<0.1	<0.1	<0.1
dibenzo(ghi)perylene	mg/kg			96.2	0.0187	103	0.112	320	340	350	1.5	0.5	0.4	0.4	0.5
indeno(123cd)pyrene	mg/kg			7.31	0.0614	9.75	0.368	27	36	41	1.4	0.4	0.2	0.2	0.4

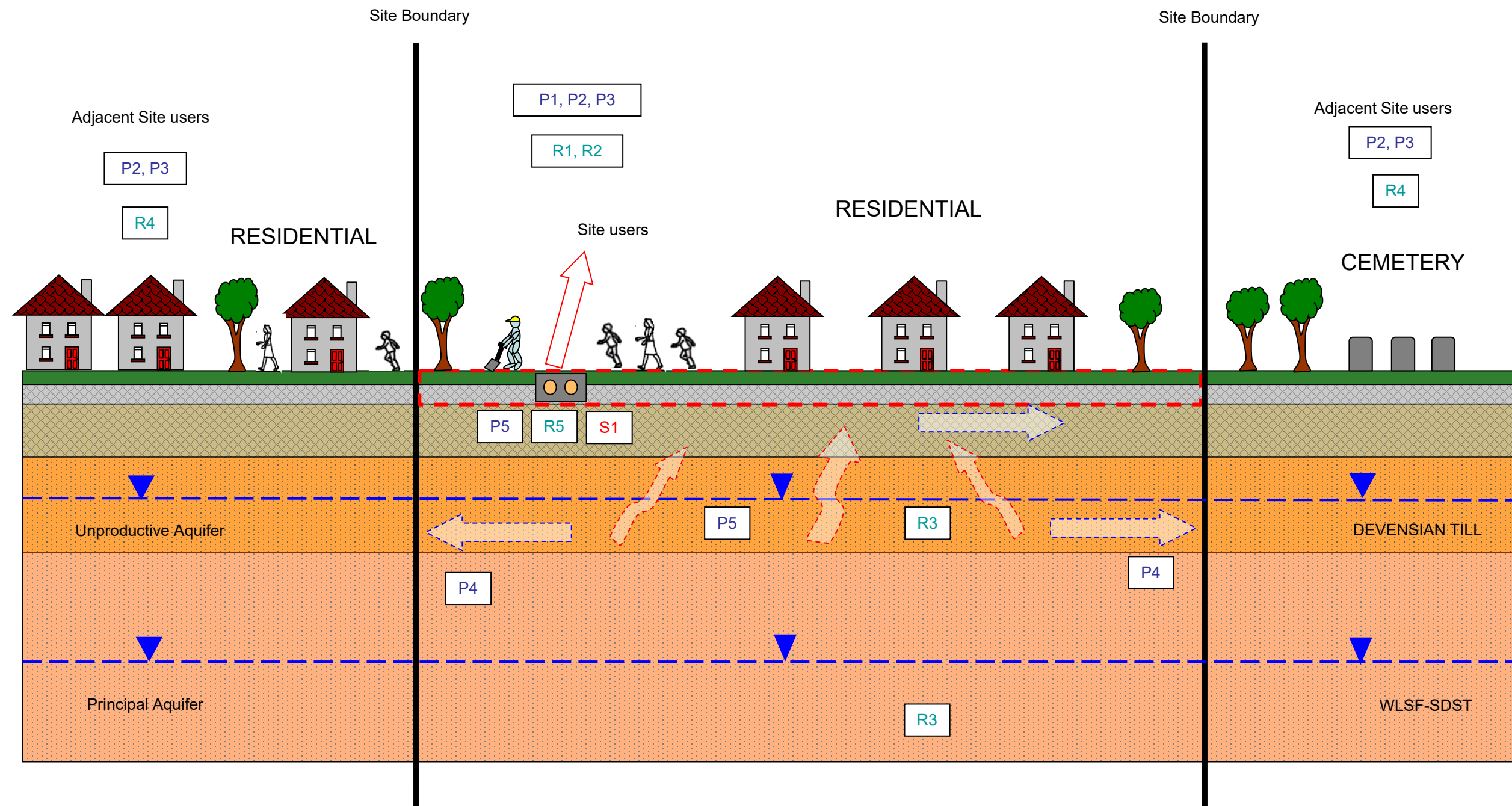


Job Name:	Langholme Heights
Job Number:	27601LG

LEACHATES								
CAS Number:	Units	Site Specific Guidelines						
Sample Ref				C227315	C227316	C227317	C227318	C227319
Determinand Name		EQS	UK DWS	WS1 ES1 0.20-0.50m	WS2 ES1 0.20-0.50m	WS3 ES1 0.20-0.50m	WS4 ES1 0.20-0.50m	TP2 ES1 0.20-0.50m
Leachate Prep (10:1 Std NRA)*								
Arsenic (Soluble)*	µg/l	50	10	8.27	11.19	6	2.16	3.11
Boron (Soluble)	µg/l	2000	1000	26.19	19.99	20.42	22.22	21.99
Cadmium (Soluble)	µg/l	0.45 - 1.5	5	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium (Soluble)	µg/l	32	50	0.95	1.1	0.8	0.69	1.08
Copper (Soluble)	µg/l	1 to 28	2000	17.75	24.76	39.07	31.32	28.42
Lead (Soluble)	µg/l	7.2	10	0.13	0.98	0.65	1.47	0.3
Mercury (Soluble)	µg/l	0.07	1	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel (Soluble)	µg/l	20	20	0.72	0.95	1.68	1.99	1.01
Selenium (Soluble)*	µg/l		10	2.38	<1.00	<1.00	<1.00	<1.00
Sulphur (Free)	mg/l			<0.2	<0.2	<0.2	<0.2	<0.2
Zinc (Soluble)	µg/l	40	5000	1.2	1.4	5.4	3.1	1.9
Cyanide (Total)*	mg/l	5	50	<0.05	<0.05	<0.05	<0.05	<0.05
Phenols (Total)	µg/l	46		<1	<1	<1	<1	<1
Sulphate as SO3	mg/l	400	250	27	7.1	7.5	2.6	13.9
Sulphide as S	µg/l	0.25		<0.10	<0.10	<0.10	<0.10	<0.10
pH	pH units			8.29	8.31	8.27	8.28	8.35
>> PAH SUITE <<*								
naphthalene*	µg/l	2.4		<0.02	<0.02	<0.02	<0.02	<0.02
acenaphthylene*	µg/l			<0.02	<0.02	<0.02	<0.02	<0.02
acenaphthene*	µg/l			<0.02	<0.02	<0.02	<0.02	<0.02
fluorene*	µg/l			<0.02	<0.02	<0.02	<0.02	<0.02
phenanthrene*	µg/l			0.04	0.05	0.02	<0.02	<0.02
anthracene*	µg/l	0.4		<0.02	0.02	<0.02	<0.02	<0.02
fluoranthene*	µg/l	0.1		0.02	0.08	0.02	<0.02	<0.02
pyrene*	µg/l			0.02	0.06	<0.02	<0.02	<0.02
benzo(a)anthracene*	µg/l			<0.02	<0.02	<0.02	<0.02	<0.02
chrysene*	µg/l			<0.02	<0.02	<0.02	<0.02	<0.02
benzo(b)fluoranthene*	µg/l			<0.02	<0.02	<0.02	<0.02	<0.02
benzo(k)fluoranthene*	µg/l	0.03		<0.02	<0.02	<0.02	<0.02	<0.02
benzo(a)pyrene*	µg/l	0.1	0.01	<0.02	<0.02	<0.02	<0.02	<0.02
dibenzo(ah)anthracene*	µg/l			<0.02	<0.02	<0.02	<0.02	<0.02
benzo(ghi)perylene*	µg/l			<0.02	<0.02	<0.02	<0.02	<0.02
indeno(123cd)pyrene*	µg/l	0.002		<0.02	<0.02	<0.02	<0.02	<0.02

	Exceedance/In Range of EQS Assessment Value
	Exceedance of UK DWS Assessment Value
	Exceedance EQS & UK DWS Assessment Value

Figure 3: Preliminary Conceptual Model



Key

S1 – Potentially Contaminated Soil – Onsite

R1 Future site Users
R2 Construction Workers
R3 Controlled waters
R4 Adjacent Site Users
R5 Infrastructure & Buried services

P1 Direct Contact
P2 Ingestion
P3 Inhalation
P4 Leaching & Migration
P5 Vertical & lateral migration of ground gas



Underground services



Ground gas migration



Leachate migration



Direct contact/ ingestion



Client: Cobalt Housing

Project: Lower House Lane, Liverpool L11 2SQ

Title: Preliminary Conceptual Site Model (CSM)

Purpose: Report

Draft

Scale (at A3)

Issue

1

Not to scale

Issuing Office: Liverpool

Drawing number

Version

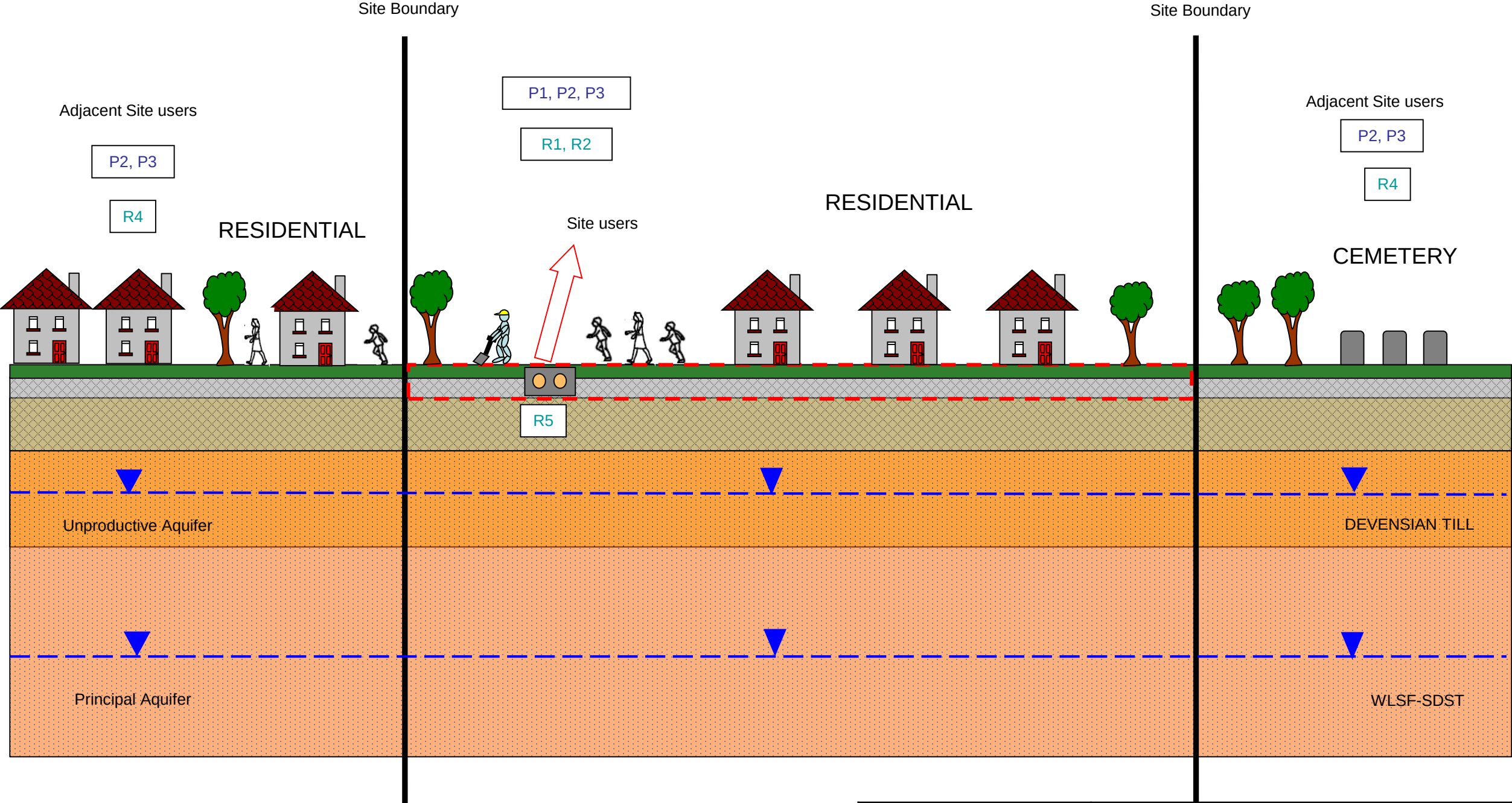
Telephone: 0151 227 3155

Fig 4.

A

Figure 6: Revised Conceptual Model





Key	
S1 – Potentially Contaminated Soil – Onsite	
R1 Future site Users	
R2 Construction Workers	
R3 Controlled waters	
R4 Adjacent Site Users	
R5 Infrastructure & Buried services	
P1 Direct Contact	
P2 Ingestion	
P3 Inhalation	
P4 Leaching & Migration	
P5 Vertical & lateral migration of ground gas	
	Underground services
	Ground gas migration
	Leachate migration
	Direct contact/ ingestion

	Client: Cobalt Housing		
	Project: Lower House Lane, Liverpool L11 2SQ		
	Title: Revised Conceptual Site Model (CSM)		
Purpose: Report	Draft		Scale (at A3)
	Issue	1	Not to scale
Issuing Office: Liverpool	Drawing number		Version
Telephone: 0151 227 3155	Fig 4.		A

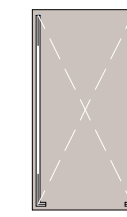
Proposed Development Plan - Drawing Ref: LH-BTP-00-SP-DR-A-3682_113.C



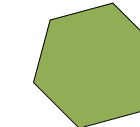
Site Plan

1 : 200

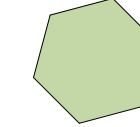
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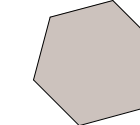
2400 x 4800mm parking space (21no)



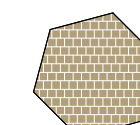
Lawn - approx. area: 723.3m²



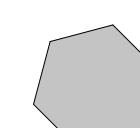
Private Garden - approx. area: 824.1m²



Block Paved Parking Space - approx. area: 694m²



Block Paving - approx. area: 211.3m²



Pavement- approx. area: 316.2m²

- Boundary Fence 1100mm - Approx. Linear Length: 256m

- Garden Trellis Fence 2100mm - Approx. Linear Length: 39m

Approx. Site Boundary Linear Length: 259m

Approx. Site Area: 4400.6m²

C	29.11.21	AW	Cycle store note and bin store included
B	07.10.21	JW	Plans updated to suit revisions of additional built in wardrobe, store moved to hall, FF under counter added in kitchen and omitted balconies to 1B2P layouts
A	16.11.20	ED	Approx. site areas and linear lengths added.
Rev	Date	Int	Description



Client:
Colbalt Housing

Project:
Langholme Heights

Description:

Proposed Site Plan

Purpose of Issue:

Feasibility

Drawn By: Checked By: Date: Scale @ A1:

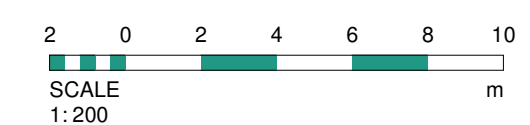
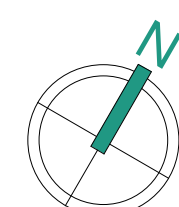
ED VJS 13.11.20 1 : 200

Job No: Status Code: Drawing No: Rev:

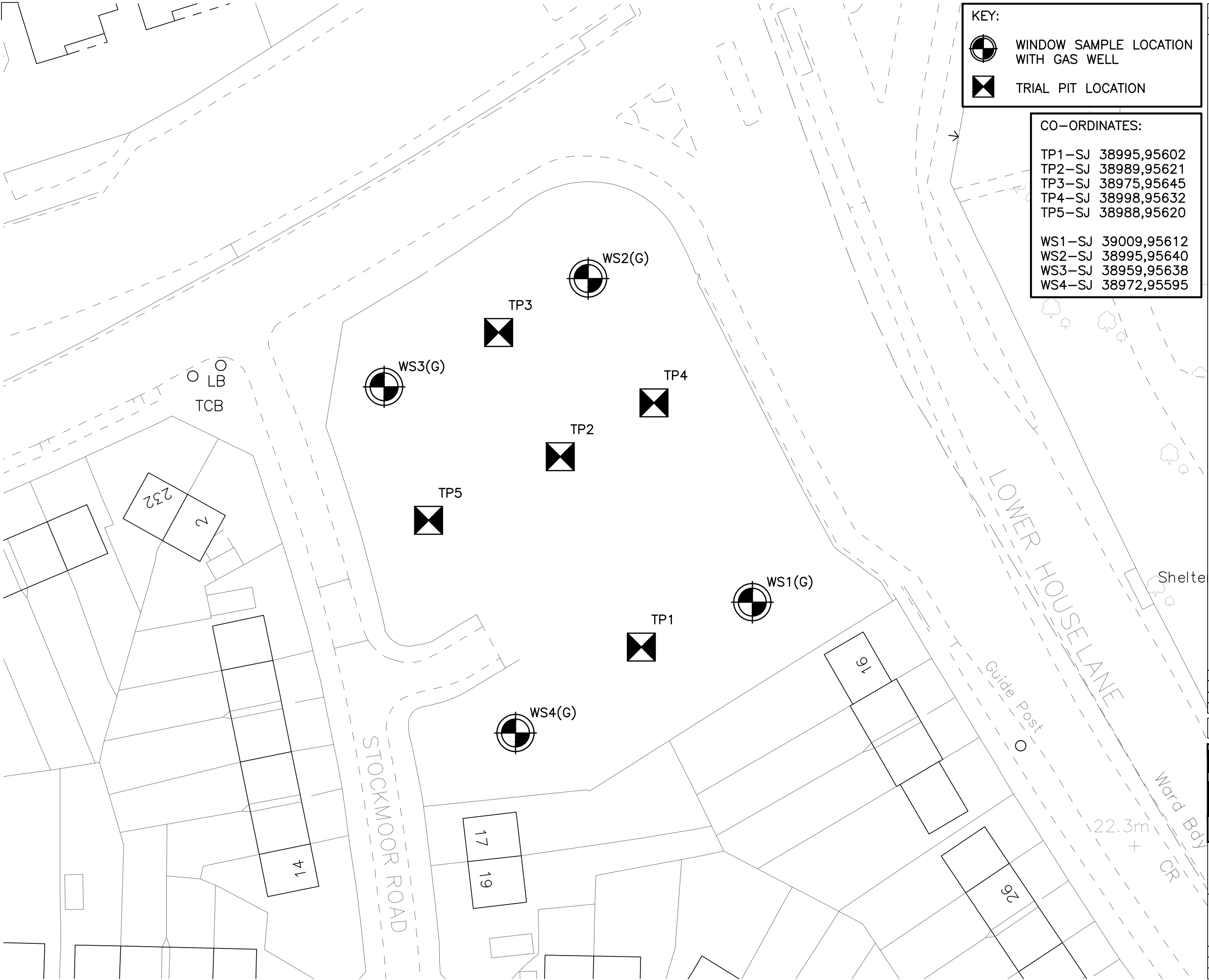
3682 S0 113 C

File Identifier:
LII-BTD-00-SP-DB-A-3683-113-C

LH-BTP-00-SP-DR-A-3682_113.C



2015 Site Investigation Locations on Existing Layout– Drawing Ref: 27601-700-P1



KEY:

 **WINDOW SAMPLE LOCATION WITH GAS WELL**

 **TRIAL PIT LOCATION**

CO-ORDINATES:

TP1-SJ 38995,95602
TP2-SJ 38989,95621
TP3-SJ 38975,95645
TP4-SJ 38998,95632
TP5-SJ 38988,95620

WS1-SJ 39009,95612
WS2-SJ 38995,95640
WS3-SJ 38959,95638
WS4-SJ 38972,95595

DO NOT SCALE OFF THIS DRAWING

GENERAL NOTES

This drawing to read in conjunction with all relevant structural and architectural drawings and specifications.

All dimensions to be checked on site by the contractor / fabricator prior to commencement of works.

All dimensions are in millimetres unless stated otherwise.

All works to be carried out in strict accordance with the engineer's specifications, relevant British Standards and where applicable Local Authorities requirements.

For final setting out information relating to grid lines and wall positions refer to the architect's drawings.

P1	04.12.15	AT	PRELIMINARY ISSUE		RW
Rev	Date	Checked	Description		By

PRELIMINARY DRAWING

 **Sutcliffe**

18-20 Harrington Street, Liverpool L2 9QA
t: 0151 227 3155 f: 0151 227 3156
e: sutcliffe@sutcliffe.co.uk w: www.sutcliffe.co.uk

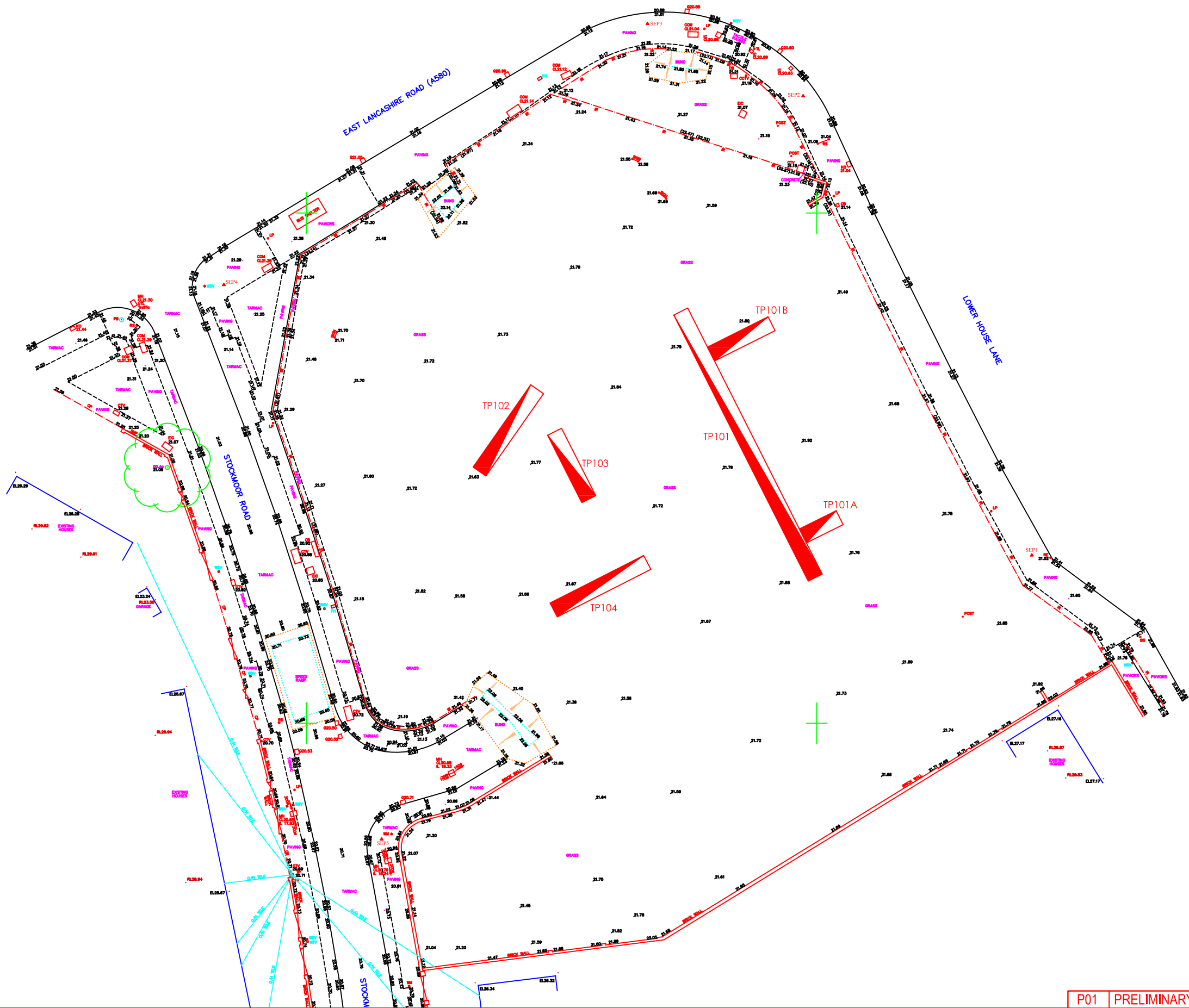
Client **LHT**

Project **LANGHOLME HEIGHTS
LOWER HOUSE LANE**

Drawing title **SITE INVESTIGATION
ON TOPOGRAPHICAL SURVEY**

Scale at A3	1:500	Drawing number	27601-700
Drawn by	R.WELSH	Revision suffix	P1
Date	04.12.15		

2020 Trial Pit Locations on Existing Layout – Drawing Ref: 31044-SUT-ZZ-XX-DR-G-720-0001





Structural & Civil Engineering
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Building Surveying
Pre Planning Services

Liverpool Head Office: 0151 227 3155
Manchester Office: 0161 817 5180
North Wales Office: 01978 664 071
London Office: 020 8016 4320

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Drawing Status

FOR INFORMATION

Client

COBALT HOUSING

Project

LANGHOLME HEIGHTS
LIVERPOOL

Drawing Title

TRIAL PITS TO INVESTIGATE
POTENTIAL CONCRETE FOUNDATIONS
ON EXISTING PLAN

P01	PRELIMINARY DRAWING	06/2020	AT	AL
Rev	Description	Date	By	Chkd
Date	Drawn By	Checked By		
JULY 2020	A TOSH	AL		
Scale at A3 NTS		Project Number 31044LG		
Sheet Number 31044-SUT-ZZ-XX-DR-G-720-0001				Revision P01

2021 Cable Percussion Boreholes Locations on Existing Layout – Drawing Ref: 31044-SUT-ZZ-XX-DR-G-720-0002

KEY

LIGHT CABLE PERCUSSION
BOREHOLE LOCATION

CO-ORDINATES

BH101 SJ38974,95643
BH102 SJ389982,95629
BH103 SJ38992,95610

Client

COBALT HOUSING

Project

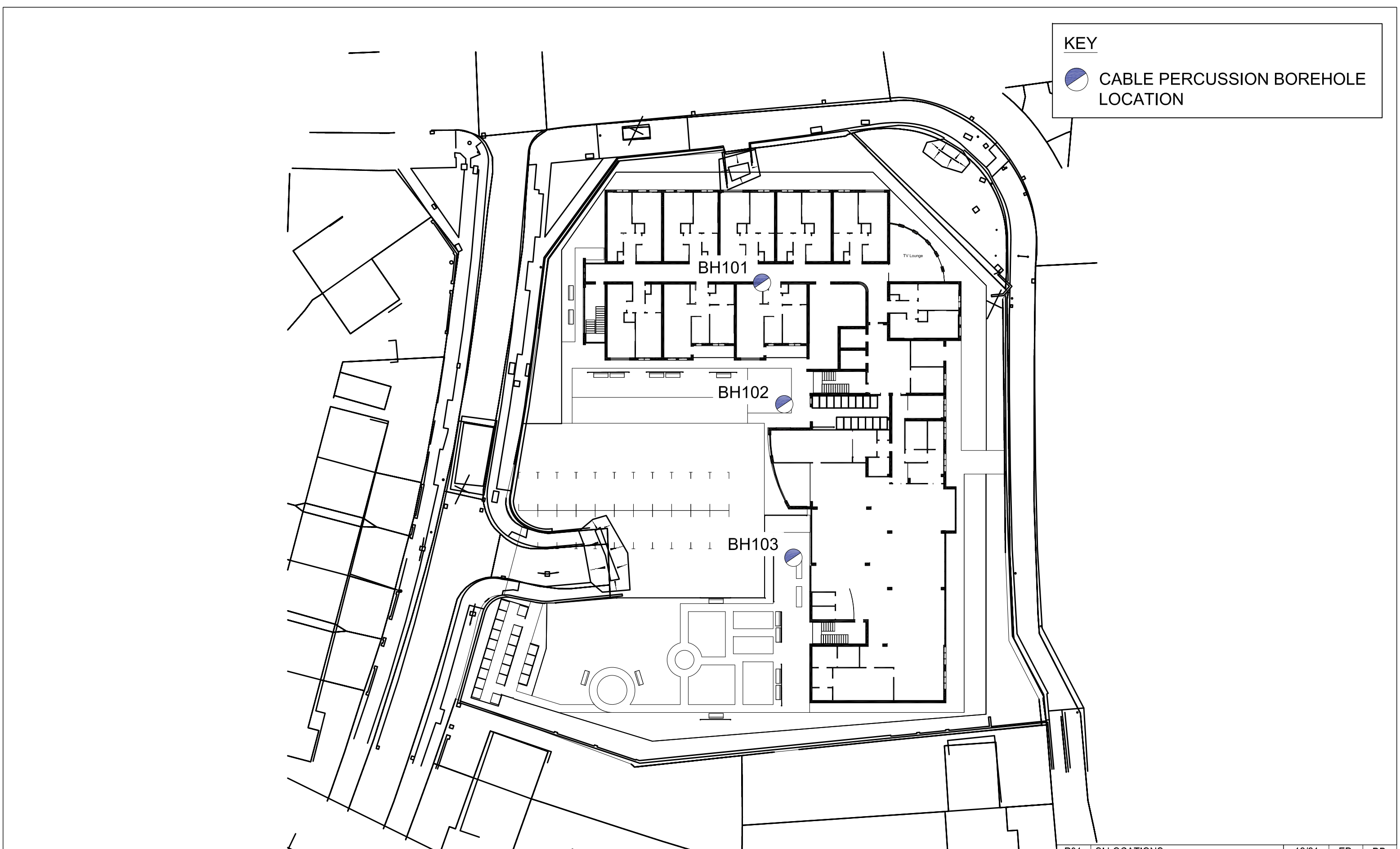
LANGHOLME HEIGHTS
LIVERPOOL

Drawing Title

LIGHT CABLE PERCUSSION
BOREHOLE LOCATIONS
ON EXISTING LAYOUT

P01	PRELIMINARY DRAWING	10/21	AT	DB
Rev	Description	Date	By	Chkd
Date	Drawn By	Checked By		
OCT 2021	A TOSH	DB		
Scale at A3 NTS		Project Number 31044LG		
Sheet Number 31044-SUT-ZZ-00-DR-G-720-0002				Revision P01

2021 Cable Percussion Borehole Locations on Proposed Site Layout – Drawing Ref: 31044-SUT-ZZ-00-DR-G-720-0003



KEY

CABLE PERCUSSION BOREHOLE LOCATION



Structural & Civil Engineering

Geotechnical & Environmental Investigations

Building Surveying

Pre Planning Services

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North Wales Office:
01978 664 071

London Office:
020 8016 4320

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Client

COBALT HOUSING

Project

LANGHOLME HEIGHTS
LIVERPOOL

Drawing Title

CABLE PERCUSSION BOREHOLES
ON PROPOSED LAYOUT

P01	SI LOCATIONS	12/21	ED	DB
Rev	Description	Date	By	Chkd
Date DEC 2021		Drawn By E.DAVIES		Checked By D.BOWEN
Scale at A3 NTS			Project Number 31044LG	
Sheet Number 31044-SUT-ZZ-00-DR-G-720-0003				Revision P01

Drawing Status

FOR INFORMATION