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GEOTECHNICAL ENVIRONMENTAL

PHASE 2 GEO-ENVIRONMENTAL REPORT

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C1570/21/E/2498	23/02/21

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Report on a Phase 2 Geo-environmental Investigation

Location:	Land adjacent to 63 Wakefield Road Moldgreen, Huddersfield, HD5 9AB
For:	Huddersfield Taxis
Consultants:	Acumen Designers and Architects Ltd
Report No.	C1570/21/E/2498 Report date: February 2022

For and on behalf of **Rogers Geotechnical Services Ltd**

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Report Summary[1]

Item	Comments	Section
Development	Construction of a new apartment block with associated car parking, hard-standing and limited soft landscaping.	1.
Geology	Made ground over superficial deposits of alluvium. Underlain by Pennine Lower Coal Measures Formation.	5.
Strata Conditions	Granular made ground present to around 1m depth over soft brown silty clays to around 2m bgl. Underlain by medium dense slightly clayey very gravelly sands.	6.1
Groundwater	None encountered during intrusive investigation. Recorded at between 2.68m and 2.64m during monitoring.	6.2 & 7.2
Foundation Design	Strip or spread foundations onto gravelly sands.	10.1
Effect of Sulphates	DC-1 concrete.	10.5
Contamination	Contamination by lead indicated to be present.	11.
Ground Gasses	Low levels of methane and carbon dioxide. Site indicated to be Characteristic Situation Level 1 and no protection measures necessary. Further gas monitoring is recommended.	11.1.2

[1] This summary should not be relied upon to provide a comprehensive review. All of the information contained in this document should be considered.

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1. Introduction

It is understood that the site is to be developed by the construction of a new apartment block with associated car parking, hardstanding and limited soft landscaping. Consequently, a site investigation has been undertaken in accordance with the instruction from the client. This work was required in order to determine the nature of the underlying soils, to assess their engineering properties and to assist in the design of safe and economical foundations for the proposed development. This investigation also takes into consideration the risk of any contamination present. This report describes the work undertaken, presents the data obtained and discusses the ground conditions in relation to the proposed works.

2. Limitations

The recommendations made and opinions expressed in this report are based on the ground conditions revealed by the site works, together with an assessment of the site and of the laboratory test results. Whilst opinions may be expressed relating to sub-soil conditions in parts of the site not investigated, for example between borehole positions, these are for guidance only and no liability can be accepted for their accuracy.

This report has been prepared in accordance with our understanding of current best practice. However, new information or legislation, or changes to best practice may necessitate revision of the report after the date of issue.

3. Desk Study

A Phase 1 Desk Study has been undertaken by Rogers Geotechnical Services (RGS) and the results were presented as report number C1570/21/E/2492 in July 2021. This report has been carefully considered during the current intrusive investigation.

4. Fieldworks

The fieldworks were undertaken on the 21st February 2022 and included the following:

- Three windowless sample boreholes with standard penetration tests.
- Three gas monitoring standpipes.

The investigatory locations are shown on the site plan which is presented in Appendix 1 to this report.

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4.1 Windowless Sample Boreholes

These boreholes were sunk using a drive-in windowless sampler. The cores were undertaken in 1m lengths and reduced in diameter from approximately 90mm for the first 1m through 80mm and 70mm for subsequent 1m increments. The recovered cores were sealed and returned to the laboratory for logging and subsequent testing. The soils were described in general accordance with BS5930: 2015 +A1: 2020 and full descriptions are given on the windowless sample records which are presented in Appendix 2. Also included on these records are the core diameters and percentages of core recovered.

4.2 Standard Penetration Tests

Standard penetration tests (SPT) were undertaken at regular depth increments within all windowless sample boreholes. The SPTs were conducted in accordance with the procedures given in BS EN ISO 22476: Part 3: 2005 +A1: 2011, and the results are summarised on the borehole record. During this work an automatic trip hammer of 63.5kg falling through 750mm was employed to drive either a cone or split barrel sampler assembly into the ground and the recovered barrel samples were retained in air tight plastic containers.

4.3 Gas Monitoring Standpipes

Gas monitoring standpipes were installed to 3m depth in all of the boreholes and the installation details are shown on the appropriate borehole records. In all cases, the monitoring standpipe consisted of a perforated pipe from the base of the borehole to 1.0m below surface, with a non-perforated pipe to ground level. The response zone was filled with pea gravel, with a bentonite seal above, and the installation was capped with a stop box cover in a concrete surround.

5. Geology

The available published geological data for the site has been examined and the following table presents the anticipated geology.

Table 1: Geological Data for the Site

Strata Type	Strata Name[2]	Previous Name[3]	Description[3]
Artificial	Made ground	N/A	Made ground indicated to underlie the site. No further details given by geological maps.
Superficial Geology	Alluvium	-	Soft to firm normally consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger, desiccated surface zone may be present.

[2] Sources: British Geological Survey (NERC) Map Sheet 77; Huddersfield; Solid and Drift Edition, and Geology of Britain Viewer [*online resource from www.bgs.ac.uk*]
[3] Sources: British Geological Survey (NERC) Lexicon of Named Rock Units [*online resource from www.bgs.ac.uk*]

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	Head	-	Head is poorly sorted and poorly stratified, angular rock debris, and/or clayey hillwash and soil creep, mantling a slope. Comprises gravel, sand and clay depending on upslope source and distance from source. Locally with lenses of silt, clay or peat and organic material.
Solid Geology	Pennine Lower Coal Measures Formation	Lower Coal Measures Formation	Interbedded grey mudstone, siltstone and pale grey sandstone, commonly with mudstones containing marine fossils in the lower part, and more numerous and thicker coal seams in the upper part.

It should be appreciated that whilst head deposits are not indicated to be present below the site, this unit of geology is noted on the map both upslope and downslope of the site. As such, it is likely that head deposits will also be present below the site.

6. Strata Conditions

In accordance with the geology of the area, the succession has been shown to include the following:

Table 2: Generalised Strata Profile

Depth m below ground level to underside of layer	Strata Type	Positions Encountered	Groundwater Strikes m below ground level
0.1 – 0.17	CONCRETE.	All	None
+0.3 – 0.95	MADE GROUND (Granular)	All	None
1.2	MADE GROUND (Cohesive)	WS2	None
1.5 – 1.9	Very soft and soft silty CLAY.	All	None
+3.45	Slightly clayey, very gravelly SAND. Locally present as clayey very sandy gravel.	All	None

'+' denotes that the strata extended below the termination depth of the investigated positions, thus the extent of the deposit is only proven to the depths indicated

6.1 General Strata

In general, predominantly granular made ground was encountered to between 0.8m and 0.95m depth, with a further deposit of cohesive made ground being recorded to 1.2m in WS2. The made ground was noted to include gravel of brick, mortar and sandstone fragments.

Below the made ground, soft to very soft yellowish brown silty clay was revealed to between 1.5m and 1.9m depth, over medium dense slightly clayey gravelly sands. It was noted that no discernible structure could be seen and the material appeared to be naturally reworked. Therefore, considering the local geology and the lack of anthropogenic material within this stratum, it is possible that this horizon represents head deposits.

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6.2 Groundwater

No groundwater strikes were observed during the site investigation. However, it should be appreciated that the normal rate of boring does not permit the recording of an equilibrium water level for any one strike, moreover, groundwater levels are subject to seasonal variation or changes on local drainage conditions.

7. Insitu Testing

7.1 Standard Penetration Tests

The standard penetration tests carried out in within the boreholes are summarised in the following table:

Table 3: Summary of Standard Penetration Tests

Strata	Depth (m)	SPT 'N' (Blows/300mm)		Comments
		Granular soils	Cohesive soils	
MADE GROUND	1.0m	–	4	SPTs indicate a very soft in-situ condition.
Silty CLAY	1.0m	–	7	SPTs indicate a soft in-situ condition.
Very gravelly SAND	2.0m	22 to 25	–	SPTs indicate granular material is in a medium dense becoming dense in-situ condition.
	3.0m	51 to 56	–	

7.2 Gas and Water Level Monitoring

The standpipes were monitored between the 28 h January to 18th February 2022. The results of the gas monitoring undertaken to date are tabulated below.

Table 4: Gas Monitoring

Location	Date	CH_4 (%)	CO_2 (%)	O_2 (%)	Flow (l/h)	Barometric Pressure (mb)	Water Level (m)	Standpipe Depth (m)
WS1	28/01/22	0.1	0.8	20.1	0.1	1020↓	-	3.0
	04/02/22	0.1	0.7	20.9	0.0	999↔	-	
	11/02/22	0.1	0.5	20.6	0.1	1025↔	-	
	18/02/22	Unable to monitor due to parked cars over position.						
WS2	28/01/22	0.1	0.1	21.5	0.1	1025↓	-	3.0
	04/02/22	0.1	0.1	21.5	0.0	1000↔	-	
	11/02/22	0.1	0.2	21.2	0.1	1025↔	-	
	18/02/22	0.1	0.3	21.1	0.1	970↓	2.68	
WS3	28/01/22	0.1	0.1	21.5	0.1	1025↓	-	3.0
	04/02/22	0.1	0.1	21.4	0.0	1000↔	-	
	11/02/22	0.1	0.2	20.8	0.1	1025↔	-	
	18/02/22	0.1	0.2	21.1	0.1	969↓	2.64	

↑ - rising pressure ↓ - falling pressure ↔ - steady pressure

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This work was undertaken using a Geotechnical Instruments (UK) Ltd. GA5000 (serial No G503524) which was last calibrated on the 5th May 2022.

8. Laboratory Testing - Geotechnical

The following programme of laboratory testing has been undertaken on samples obtained during this investigation:

- Determination of water content — BS EN ISO 17892-1:2014
- Determination of liquid and plastic limits — BS EN ISO 17892-12:2018
- Linear Shrinkage — BS 1377: 1990: Pt2: 6.5
- Soluble sulphate content — BS 1377: 1990: Pt3: 5
- pH value — BS 1377: 1990: Pt3: 9

The test results are presented in Appendix 3 and are summarised below:

Table 5: Summary of Geotechnical Test Results

Test type	Number of tests	Range of results		Comments
Water content determinations	2	26% & 29%		
Index properties (1 Point)	2	LL PL PI LS	51% & 65% 22% & 23% 29% & 42% 11% & 13%	Clay of high plasticity. Consistency index 0.9. NHBC Class: Medium and high.
Soluble sulphate & pH	3	SO_4 pH	81 to & 270 mg/l 8.5 to 8.8	DS-1, AC-1 (Mobile water).

In cohesive soil the approximate cohesion, c_u, and coefficient of consolidation, m_v, may be obtained from the equivalent SPT 'N' value using the following expressions (Stroud 1975).

$c_u = f_1 N$

$m_v = \frac{1}{f_2 N}$

where:

c = cohesion (kN/m^2).
m_v = Coefficient of consolidation (m^2/MN).
f_1 & f_2 = factors based on plasticity index.
N = SPT 'N_{300}' value.

For the cohesive soils revealed at this site the highest (worst case) plasticity index[4] of 42% could be employed, which suggests an f_1 value of 4.4 and an f_2 value of 0.44.

[4] See paragraph 6.2 'Index Property Tests'

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8.1 Geotechnical Properties

The idealised geotechnical properties employed in design are summarised below.

Table 6: Summary of Geotechnical Properties

Property		Range of values	Comments
Volume change potential (NHBC)		High	Silty CLAY.
Consolidation characteristics	m_v	0.32m^2/MN	Stroud (1974) where $m_v = 1/f_2N$. High compressibility.
Concrete classification		DC-1	Brownfield locations (mobile water).

9. Laboratory Testing - Environmental

A suite of testing was conducted on samples from across the site and the following regime was undertaken.

- Metals – Cd, Cr^{VI}, Cu, Hg, Ni, Pb, V and Zn.
- Semi and Non-Metals - As, Se, Free CN^- and Phenols.
- Polycyclic aromatic hydrocarbons (PAHs).
- Petroleum hydrocarbons (TPHs).
- Others – pH, organic content and total/soluble SO_4^{2-}.
- Asbestos identification.

This testing was undertaken by Eurofins Chemtest Ltd and the results of all of the chemical testing are presented in Appendix 3 of this report.

10. Discussion of Ground Conditions - Geotechnical

It is understood that the site is to be developed by the construction of a new apartment block with associated car parking, hardstanding and limited soft landscaping. At the time of writing this report the precise layout and method of construction is not known, thus the discussion below is of a generalised nature.

It cannot be recommended that foundations be constructed directly within the made ground or weak near surface soils associated with the superficial deposits. These soils are present in a weak and variable condition, such that excessive total and or differential settlement could occur under moderately light surface loading.

10.1 Strip or Spread Foundations

The results of this investigation indicate that medium dense slightly clayey very gravelly sands are present at around 2m depth. It is considered that this material will provide a suitable bearing stratum, provided that the foundations are placed within soil generally described as being present in

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a medium dense insitu condition. It is considered that strip or spread foundations could be constructed in such soils at around 2.0m depth and be designed assuming an allowable increase in stress given in the following table.

Table 7: Allowable Increase in Stress

Foundation Type		Strip Footings		Spread Footings	
Foundation Breadth	B (m)	0.6	1.0>	0.6	1.0>
Foundation Depth	D (m)	2.0		2.0	
Allowable increase in stress	(kN/m²)	120	160	150	200

The allowable increase in stress given above assumes settlements of less than 25mm, with an SPT 'N' value of 20 at the foundation depths and provided that the underlying soils are carefully inspected immediately final trimming has taken place.

Should any soft or weak material be encountered they should be locally removed and replaced with lean-mix concrete or compacted granular soil. In addition, if the excavations are required to stand open for any period of time then a blinding layer of lean-mix concrete should be placed in the excavation bases. This expedient will reduce softening or loosening of the sub-grade due to the ingress of surface water.

The stability of excavation faces cannot be guaranteed thus temporary support to the excavation faces may become necessary unless the foundations are constructed using trench-fill techniques. In this method the foundation trenches should be excavated, inspected and backfilled with concrete as a continuous operation. Under no circumstances should operatives be allowed to enter unsupported excavations.

Particular care will be required when excavating close to footings of adjacent buildings. If possible, foundations should be arranged such that they are located away from adjacent foundations. However, if this is not possible, the new foundations will need to be placed deeper than the existing footings. This will prevent additional loads being imposed which could result in further settlement occurring on the neighbouring buildings. Moreover, caution will need to be exercised to ensure that loss of support to the neighbouring footings does not occur whilst undertaking the excavations. It may be necessary to provide temporary support to the excavation sides if the sides are felt to be unstable.

Should seepages of groundwater be encountered it is considered that they could be dealt with using a simple form of de-watering. Such a system could include the excavation of sumps from which the water could be pumped.

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10.2 Volume Change Potential

It should be appreciated that the cohesive soils revealed at this site possess a medium to high volume change potential under the guidance of the NHBC standards. Therefore, it is will be necessary to ensure that heave protection is provided against the side of footings in accordance with the Chapter 4.2 of the NHBC standards[5]. The methodology provided in the guidance will require the identification of any trees, still present at, or recently removed from, the site and the distance from the proposed foundations. In addition, heave protection should be extended to below the underside of the floors and beams. However, as the foundations are to be to constructed on granular soils (gravelly sands), heave/shrink potential of the underlying will not represent a significant issue.

10.3 Ground-floors

In light of the weak near surface soils revealed at the site, it is not recommended that ground bearing ground floor slabs be employed. In this instance it would be necessary to suspend floors between foundation positions, such that the floor loads are transmitted via the foundations to competent soils at depth.

10.4 Hard-standing Areas

It is considered that any hard-standing at the site could be constructed employing traditional pavement design. A design California Bearing Ratio (CBR) of 3% could be employed in the pavement design[6]. However, it is recommended that proof rolling of the sub-grade be undertaken to establish the suitability of the soils, to expose any soft or weak ground and to ensure the sub-grade is well compacted prior to construction. Any areas of soft or weak ground should be remediated by increasing the sub-base thickness. Alternatively, weak material could be locally removed and replaced with a compacted granular capping layer. If construction were to be undertaken during the winter or after periods of prolonged rainfall, it may be prudent to employ a geotextile and/or a geogrid between the sub-base and sub-grade.

10.5 Effect of Sulphates

In view of the nature of the underlying soils it is considered that the design sulphate class be assessed with reference to Table C2[7], which is provided in BRE Special Digest 1, *Concrete in aggressive ground*: Part C. On the basis of this table and considering the soluble sulphate contents recorded, it can be shown that well compacted buried concrete should be designed in accordance with Class DS-1 requirements. Assuming mobile groundwater, the table also indicates that the aggressive chemical environment for concrete (ACEC) classification is AC-1.

[5] NHBC Standards, Chapter 4.2, *Building near trees*
[6] Table 11.1, *Reproduction of TRRL Report LR1132 (1984)*, Smith (2006), Smith's Elements of Soil Mechanics, 8th ed.
[7] Table C2, *Aggressive Chemical Environment for Concrete (ACEC) classification for brownfield locations*

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In order to evaluate the design chemical (DC) class for the buried concrete at this site reference should be made to Table D1[8], which can be found in Part D, *Specifying concrete for general cast-in-situ use,* of BRE Special Digest 1. From this table it may be shown that for an intended working life of at least 50 years the concrete design class DC-1 is required.

11. Discussion of Ground Conditions - Environmental

11.1 Discussion of Test Results

It is understood that the site is to be developed by the erection of an apartment block with associated car parking, hard-standing and limited soft landscaped areas. Consequently, the site may be classified as residential without plant uptake.

11.1.1 Soil Samples

The results of the chemical testing undertaken on soil samples obtained during this investigation have been compared to the ATRISK soil screening values (SSVs) as compiled by WS Atkins plc. With respect to the results it should be appreciated that the soil organic matter (SOM) content for the samples tested was found to range between 4.0 % and 6.9%. On this basis, it is considered that the screening values associated with 1% SOM should be adopted. These values have been derived in such a way as to adhere to the principles within the revised CLEA model and include the most current release of the SGVs. A list of subscribers is provided within the website[9] and these include many local authorities.

A comparison of the results of the testing, together with the data given above, can be found within Appendix 3. These results indicate the following:

Table 8: Summary of Contaminated Areas

Location	Depth (m)	Contaminants found to be exceeding SSVs (Residential without plant uptake)
WS1	0.3	Lead.
WS2	0.5	None.
WS3	0.5	PAHs [Chrysene, benzo(b)fluoranthene].

Concentrations of chromium(VI), free cyanide, phenols (total), some polycyclic aromatic hydrocarbons and all total petroleum hydrocarbons (aliphatic C5 to C44; aromatic C5 to C44) were below the detection limits for the tests. Detectable levels of all other contaminants were recorded, but these fell below the associated Atrisk Soil Screening Values. In addition, no asbestos was detected within the soil samples tested.

It should be appreciated that the soil screening values for PAHs and TPHs (where appropriate) represents vapour saturation limits. The inhalation of vapour pathway contributes less than 10% of

[8] Table D1, *Selection of the DC Class and the number of APMs for concrete elements where the hydraulic gradient due to groundwater is 5 or less: for general in-situ use of concrete.*
[9] http://www.atrisksoil.co.uk/pages/general/subscribers.asp

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total exposure, which is unlikely to significantly affect the combined assessment criterion[10]. In view of this, the ATRISK soil SSVs notes that the users may wish to consider using a combined assessment criterion if free product is not observed, the values for which are also provided on the summary of contamination analysis. It is therefore considered that the criteria for no free product should be adopted for the PAHs and TPHs at this site. The results of the contaminants found to exceed these screening values are tabulated below:

Table 9: Summary of Areas Contaminated by PAHs & TPHs

Location	Depth (m)	Contaminants found to be exceeding SSVs (Residential without Plant Uptake)
WS1	0.3	None
WS2	0.5	None
WS3	0.5	None

On the basis of the above information, the results of the investigation indicate that a potential 'hot-spot' of contamination by lead is present within the area of WS1.

11.1.2 Gas Concentrations

With respect to ground gas, the results of the monitoring visits indicated a maximum concentration of 0.1% methane, with concentrations of carbon dioxide ranging between 0.1% and 0.8%, in association with oxygen levels of between 20.1% and 21.5%. It should be appreciated that on non-contaminated sites there is generally about 20% by volume of oxygen, associated with low levels of carbon dioxide. In addition, a maximum flow rate of 0.1 litres per hour was recorded and will be employed in the following calculations.

The principal driving force for initiating the movement of gas in the ground is a change in barometric pressure. The most onerous gas condition on a site is usually observed on days of low or falling barometric pressure, preferably below 1000mb. It has been noted that measurements undertaken solely during high pressure conditions may be of lesser value. At this site the readings undertaken to date were at atmospheric pressures of between 969mb and 1025mb.

In order to establish the gas screening value (GSV) for carbon dioxide or methane, the maximum gas concentration (expressed as a decimal) is multiplied by the borehole flow rate (l/hr). In this case 0.1% (0.001) methane was recorded along with 0.8% (0.008) carbon dioxide, in association with a maximum flow rate of 0.1 l/hr. This results in a GSV of 0.0001 l/hr for methane and a GSV of 0.0008 l/hr for carbon dioxide.

In accordance with Table 2 of BS8485: 2015, *Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings,* the site may be characterised as *Characteristic Situation Level 1*. It is therefore considered that there is a very low risk of harm to end users and site operatives and some special precautionary measures are required in accordance to Table 8.6, *Typical scope of gas protection measures,* of CIRIA report C665.

[10] Ref: ATRISK soil, SSVs derived using CLEA v1.071 for 1% SOM, Residential without home grown produce land use, 23.06.17.

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With regard to the number of monitoring visits required reference is made to Tables 5.5a and 5.5b of CIRIA report C665 (2007)[11]. Accepting that the proposed development is of moderate sensitivity and that the generation potential is very low, these tables suggest that 6 readings could be undertaken over a period of 2 months. However, C665 notes that *not all sites will require gas monitoring for the period and frequency indicated in Tables 5.5a and 5.5b.*

In this case, a total of 4 monitoring visits were undertaken over a five-week time period and for the purpose of this assessment, it is considered that the site can be provisionally classified as Characteristic Situation Level 1. In order to fully characterise the site, it is recommended that two further monitoring visits are undertaken within the next month as recommended by the CIRIA report C665 (2007).

In light of the above, it is considered that following the additional monitoring visits, should there be no significant change in ground gas conditions, the site can be fully classified as Characteristic Situation Level 1. However, in the first instance it may be prudent to budget for gas protection measures until the monitoring regime has been completed.

11.2 Site Specific Risk Assessment

11.2.1 Approach

The presence of contamination hazards and the risks associated with them should be assessed in accordance with industry practice and the 'suitable for use' approach. This has been conducted with reference to The Department for Environment, Food and Rural Affairs (DEFRA) and The Environment Agency[12] advice on the assessment of risks arising from the presence of contamination in soils and using the source-pathway-receptor approach.[13] This method dictates that there must be a risk of contaminant produced at a 'source' in sufficient concentration to cause harm and there must be a 'pathway' for the contaminant to reach an identifiable 'receptor' for the linkage to be proved and a contamination hazard to be considered present. Not all substances are contaminants and not all contaminants are considered to be a risk. Indeed, DEFRA and The Environment Agency state that 'a contaminant is a substance which has the potential to cause harm, while a risk itself is considered to exist if such a substance is present in sufficient concentration to cause harm and a pathway exists for a receptor to be exposed to the substance.'[14]

[11] Adapted from tables 5.5a and 5.5b of CIRIA C665, 2007, *Assessing risks posed by hazardous ground gas to buildings, p60.*
[12] R&D Publication CLR 8, 'Assessment of Risks to Human Health from Land Contamination: An overview of the Development of Soil Guideline Values and Related Research'.
[13] The pollution linkage approach was developed by 'Circular 2/2000 Contaminated Land: Implementation of Part II of The Environmental Protection Act 1990' which provides meanings for the terms contained in The Environmental Protection Act 1990 Part IIA, the primary legislation for addressing the issues of contaminated land.
[14] See 'Circular 2/2000 Contaminated Land: Implementation of Part II of The Environmental Protection Act 1990', appendix A.

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11.2.2 Conceptual Ground Model and Risk Assessment

In view of the results of the chemical testing undertaken the conceptual site model is presented accordingly as Table 10. Sources of contamination include the following:

On-site – Made Ground (Localised lead hotspot).

The preliminary risk assessment has been evaluated with reference to the following ratings and definitions:

N/A - A source-pathway-receptor linkage is not considered to exist and therefore a risk assessment is not required.

Low - A pollution linkage is unlikely and/or the likelihood of harm occurring is low and of minor consequence.

Moderate - The linkage exists but the likelihood of harm occurring is not considered to be significant although remedial action may be necessary.

High - The linkage exists and the available data indicates that significant harm may be caused and remedial action could be necessary.

The results of the risk assessment are presented in Table 10.

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Table 10: Conceptual Site Model and Site Specific Risk Assessment [Contamination: Localised lead]

Conceptual Site Model			Site Specific Risk Assessment	
Pathways	**Receptor**	**Linkage Present?**	**Risk Rating**	**Notes**
Direct contact/dermal absorption/soil ingestion	Operative	Yes – Localised contamination found to be present at the site and contact with soil likely during works.	High	Some localised contamination is present in the soils underlying the site. Precautionary measures will be required during the construction phase. Remediation will be required to either remove the contamination or break pathways. However, as the site is anticipated to be secured during the development phase, contamination is not anticipated to affect neighbours.
	End User	Yes – Localised contamination found to be present at the site and site to be developed into an apartment block with landscaped areas.	High	
	Neighbours	Yes – Localised contamination found to be present at the site and a populated residential and commercial area surrounds the site.	Low	
Inhalation of Dust/Vapours	Operative	Yes – dust may be derived from contaminated soils.	High	Some contamination is present underlying the site. Precautionary measures will be required during the construction phase. Remediation will be required to either remove the contamination or break pathways.
	End User	Yes – dust may be derived from contaminated soils.	High	
	Neighbours	Yes – contamination found to be present at the site and residential and commercial properties located within 250m radius of the site and poss ble inhalation of dust during the works.	High	
Ingestion of fruit/vegetables and/or waters	Operative	No – no ed ble plants or contained water sources in the area of the proposed new works.	N/A	Some contamination is present underlying the site. Precautionary measures will be required during the construction phase. Remediation will be required to either remove the contamination or break pathways. However, the contamination at the site is considered to be of limited mobility, therefore the l kelihood of contamination affecting neighbouring gardens is considered low risk.
	End User	Yes – contamination found to be present at the site and site to be developed into an apartment block with limited landscaped areas.	Moderate	
	Neighbours	Yes – contamination found to be present at the site and residential area adjoins the site.	Low	
Migration of hazardous gases via permeable strata or shallow mining activity	Operative	Yes – low concentrations of methane and carbon dioxide have been found to be present at the site (assuming *Characteristic Situation Level 1*).	Low to moderate	Low concentrations of harmful gases (methane and carbon dioxide) were detected at the site. If ground gas conditions remain the same, no special precautionary measures are deemed to be required.
	End User		Low to moderate	

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	Neighbours	No – whilst concentrations of ground gas have been found to be present, no deleterious material has been encountered within the soils. Therefore, the site is not considered to represent a generating source of ground gas.	N/A	
Spillage/loss/run off direct to receiving water	Controlled Waters	Yes – known controlled waters within 250m. However, localised contamination by lead is not anticipated to be significantly mobile.	Low	Some contamination is present underlying the site. Remediation will be required to either remove the contamination or break pathways. Old services to be removed or capped.
Migration via permeable unsaturated strata	Controlled Waters	Yes – Secondary A Aquifer is present beneath the site. However, the site is underlain by cohesive soils of low permeability. Localised contamination by lead is not anticipated to be significantly mobile.	Low	
Run off via drainage/sewers etc	Controlled Waters	Yes – old services may be present on site. However, the site is underlain by cohesive soils of low permeability. Localised contamination by lead is not anticipated to be significantly mobile.	Moderate	
Direct contact with contaminated soils	Plants	Yes – some contamination present at the site which may affect plants.	High	Some contamination is present underlying the site. Remediation will be required to either remove the contamination or break pathways.
Uptake via root system			High	
Direct contact with contaminated soils	Building Materials	Yes – the contamination revealed at the site may represent a risk to building materials or plastic water pipes. Moreover, testing indicates that the aggressive chemical environment for concrete classification is AC-1.	Moderate (plastic services)	Please see section 11.3.3 for information on good building practice.
Direct contact with contaminated groundwater			Low (buried concrete)	
Exposure to Radon	Operative / End User	No – not in a radon affected area.	N/A	The publication BR211 states that no protection measures are necessary.
UXO Risk	Operative / End User	Yes – the Zetica[15] online maps indicate that the site is at low risk from UXO.	Low	No further action required.

[15] Pre-desk study assessment [*online resource from www.zeticauxo.com*].

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11.3 Indicative Remediation Strategy

In view of the site-specific risk assessment it is considered that remediation will be required at this site. Such a strategy should include the following main elements.

11.3.1 Remediation Objectives

Based on the site-specific risk assessment the object of the remediation is likely to be as follows.

- To protect the site operatives during the construction process from the ingestion of soil or dust, dermal contact with the soil and inhalation of dust and vapours.
- To protect the end user from the ingestion of soil or dust, dermal contact with the soil and inhalation of dust.
- To protect neighbours from the inhalation and ingestion dust during the construction process.
- To protect operatives, end users and neighbours from the ingestion of contaminated fruit and vegetables.
- To protect plants from direct contact with contamination and prevent uptake via root system.
- To ensure that contamination cannot enter the former services occupying the site which may return to controlled waters.
- To protect plastic services from being penetrated by, or degrading due to the presence of, contamination in the soil.

11.3.2 Development Requirements

Whilst the precise nature of this development has not been finalised it is understood that the site is to be developed by the erection of an apartment block with associated car parking, hard-standing and limited soft landscaped areas. In view of the above a site-specific remediation strategy should be undertaken after the proposed development has been finalised. However, for preliminary design and costing the following remediation proposals are offered.

11.3.3 Outline Strategy

In order to fulfil the objectives defined above it is likely that the following remedial strategy could be utilised. It is recommended that a pragmatic approach be undertaken, with observational techniques being employed at each stage of the work.

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Ground-works

During the ground-works phase of the development, protection to the site operatives is required. The risk to site operatives is considered under the Health and Safety at Work Act 1974, together with regulations made under the act, which includes the Control of Substances Hazardous to Health (COSHH) regulations. Therefore, the risks to site personnel must be considered under the Construction Design and Management (CDM) regulations at the planning stage and be included in the contractor's Health and Safety Plan and site-specific Method Statements. These documents should include the following main elements.

- Site operatives at all levels should be made aware of the hazards of working with contaminated soils.
- Personal hygiene facilities, including washing and messing, must be provided and site operatives be encouraged to use them.
- Where work is undertaken in dry weather the site should be dampened down to avoid dust. In addition, dust masks must be provided to all site operatives for use in dry weather.
- In order for contaminated soils to be disposed of to an appropriate landfill, it may be necessary to carry out Waste Acceptance Criteria (WAC) testing in accordance with BS EN 12457.
- Any stockpiles of contaminated soil on site should be sheeted over to prevent excessive amounts of airborne dust and cross contamination of imported fill.
- Where vehicles are transferring soil to the landfill site they should be covered to prevent contamination of the surrounding area by dust.
- Where work is undertaken in wet weather, vehicle and wheel washing facilities are required to ensure that the vehicles leaving the site do not transfer contamination to surrounding areas.

On completion of the ground-works a careful site inspection of the sub-grade would be required. Should visual or olfactory evidence of contamination be revealed then further testing may become necessary.

Construction

During the construction phase of the contract the following items are required to protect the end user from the potential contaminants revealed at this site.

- Beneath buildings, pavements and hard-standings clean inert granular sub-base should be employed.
- Any redundant services revealed at this site should be de-commissioned and piped services sealed. Any existing services that are to be employed in the new development should be carefully inspected to ensure that they are serviceable.
- New plastic services should be constructed in a surround of clean inert material and selected in accordance with the recommendation given in the United Kingdom Water Industry Research (UKWIR) website under Report Ref. No. 10/WM/03/21 - 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites'. The statutory water authority for the area in which site is located may have a risk assessment form to complete which allows these recommendations to be met. However, further determinand specification contamination testing may be necessary.
- For buried concrete the results of the sulphate and pH testing indicate that the design sulphate class for the site should be DS-1.

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- Whilst the results to date indicate a low risk from bulk ground gasses, for budgeting purposes (assuming *Characteristic Situation Level 2),* it is anticipated that the remedial measures could include a gas resistant membrane in conjunction with a passive sub-floor dispersal layer. Clearly, if further monitoring indicates the levels/flow rates of ground gas remaining within the parameters of Characteristic Situation Level 1, then these measures will not be required.

Landscaped Areas

It is understood that there is likely to be some limited soft landscaped areas as part of the development. In view of this and the potential contamination on site, it is considered that landscaped areas will require some remediation. This could include the provision of a clean cover system including a capping layer of say 500mm of inert material, which will put the contaminated ground out of the end users' dig range. At the base of this layer, a granular capillary break of say 100mm of free draining granular soil should be placed in order to prevent mobile contamination rising upward. This expedient should also provide a suitable root barrier to isolate the plants from the underlying contaminated ground.

11.4 Fill Materials

It should also be appreciated that any fill material, either site-won or imported, to be employed at the site should be subjected to the following assessment to determine its suitability.

Fill materials should be initially screened, by a suitably qualified engineer to establish that:

- It is a suitable growing media if it is to be employed as such, including compliance with BS3882 (2015)
- It is free from obvious contamination i.e. visual or olfactory evidence
- It has not come from areas where Japanese Knotweed or other invasive or injurious plants are suspected to be growing
- It is not a statutory nuisance, such as being odorous
- It is free from unsuitable material i.e. whole bricks, brick ties, timber or glass.

It should also be appreciated that any fill should be subjected to validation testing to assess its suitability. The following table has been taken from YALPAG[16] documentation and may be used as a guide. Depending on the origin and nature of the material, not all fill will require the sampling frequency and testing indicated, although this should be in agreement with any regulatory bodies (such as the Local Authority).

[16] *YALPAG Technical Guidance for Developers, Landowners and Consultants – Verification Requirements for Cover Systems V4 .1* Appendix 1a, June 2021

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Table 11: Validation Sampling and Testing		
Fill Type	**Frequency**	**Minimum Determinands**
Virgin Quarried Material	1 or 2 depending on the type of stone utilised, to confirm the inert nature of the material.	Standard metals/metalloids (should include as a minimum As, Cd, Cr, CrVI, Cu, Hg, Ni, Pb, Se, Zn)
Crushed Hardcore, Stone, Brick	Minimum 1 per 500m³	Standard metals/metalloids (as above), PAH (16 USEPA speciation), asbestos, total TPH. Any additional analysis dependant on the history of the donor site (e.g. phenol, total cyanide, BTEX, MTBE).
Greenfield/ Manufactured Soils	Minimum 3 Dependent on source and receptor, between 1 per 50m³ and 1 per 250m³	Standard metals/metalloids (as above), PAH (16 USEPA speciation), asbestos, pH and soil organic matter (SOM) (or calculated from total organic carbon (TOC)).
Brownfield/ Screened Soils	Minimum 6 Dependent on source and receptor, between 1 per 50m³ and 1 per 100m³	Standard metals/ metalloids (as above), PAH (16 USEPA speciation), TPH (CWG banded), asbestos, pH and SOM (or calculated from TOC). Any additional analysis dependant on the history of the donor site (e.g. phenol, total cyanide, BTEX, MTBE).

The screening values for the above regime should also be agreed with any regulatory bodies; however, the following is recommended in the first instance.

Table 12: Fill Screening Values			
Contaminant	**Screening Value (Residential without Plant Uptake) (mg/kg)**		**Reference**
	1% SOM	**6% SOM**	
As	39.9	37	Atrisk^{SOIL} SSVs
Cd	149	149	Atrisk^{SOIL} SSVs
Cr(VI)	20.5	20.5	Atrisk^{SOIL} SSVs
Cu	9060	9060	Atrisk^{SOIL} SSVs
Hg	10	20.3	Atrisk^{SOIL} SSVs
Ni	188	188	Atrisk^{SOIL} SSVs
Pb	313	313	Atrisk^{SOIL} SSVs
V	357	357	Atrisk^{SOIL} SSVs
Zn	47000	47000	Atrisk^{SOIL} SSVs

Please see summary sheet within Appendix 4 for full screening values including PAHs & TPHs.

The above screening values should be considered with respect to the Soil Organic Matter (SOM) of the subject material i.e. 1% SOM would be typical for granular fill and 6% SOM for topsoil. Testing should comply with UKAS and MCERTS, where applicable, and undertaken by an accredited laboratory.

Where the material has been derived from a commercial company, certificates or other industry quality protocol compliance i.e. WRAP should be obtained. However, it will be necessary to ensure that this documentation specifically related to the material being imported, it is no more than two months old and complies with the screening and frequency requirements given above.

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Suitable fill materials should be either placed immediately or sufficiently quarantined to prevent cross-contamination. If it is necessary, the quarantined material should be placed on appropriate sheeting and covered to prevent it becoming mixed with contaminated soils or dust, or penetrated by mobile contaminants.

11.5 Verification Report

In order to demonstrate that the remedial works and provision of clean cover has been sufficiently carried out where applicable, it will be necessary to produce a verification report for submission to any statutory authorities.

It will be necessary for this report to include the following:

- Characterisation of the suitability of the clean material including the derivation of the material, comments from a visual screen, the tests results of chemical screening, delivery tickets where appropriate and the conditions by which the clean material has been stored and handled on site.

- Photographic and logged evidence the clean material has been handled on site and placed in a sufficient thickness over areas where made ground remains. This may be either at the time of placement or after placement by means of hand excavated trial pits. Photographs should include visual site references or reference boards to prove the location and date taken. A measurement reference should be visible in the photographs to substantiate the thickness of material placed. Please note that it may also be necessary to undertake a topographical survey and the requirement for which should be checked with any statutory authorities.

The report detailed above should be produced by a suitably qualified engineer. The number of verification areas for the development should be confirmed with any statutory authorities for the site.

12. Recommendations for Further Work

- This report should be forwarded to the relevant authorities as soon as practicable to ensure they have sufficient time to review and discuss any issues.
- Completion and reporting of recommended additional gas monitoring.
- Discussions with ground work contractors in relation to the requirement for testing of materials to be disposed off-site (Waste Acceptance Criteria) and the suitability of imported materials.
- Discussions with service providers regarding suitable materials for pipe work given the nature of chemical determinands found within the soils on site.
- Produce a validation report to demonstrate that the geo-environmental risks discussed in this report have been mitigated.
- Detailed design of the sub-structure.

Clearly Rogers Geotechnical Services Ltd would be happy to offer advice with respect to the above and assist where necessary.

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13. References

- British Geological Survey (NERC) (2022), BGS, Keyworth.
  - Geology of Britain Viewer: (*http://maps.bgs.ac.uk/geologyviewer_google/googleviewer.html)*
  - Lexicon of Named Rock Units:
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- British Standards Institution (1990) BS1377: *British standard methods of test for soils for civil engineering purposes,* B.S.I., London.

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- British Standards Institution (2015 +A1: 2020) BS 5930: *Code of practice for ground investigations,* B.S.I., London.

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- Building Research Establishment (BRE) Special Digest 1 (2005), Third Edition: Concrete in aggressive ground, BRE Press, Garston.
  - Part C: *Assessing the aggressive chemical environment.*
  - Part D: *Specifying concrete for general cast-in-situ use.*

- Department for Environment, Food and Rural Affairs and the Environment Agency (2009) DEFRA Science Report – SC050021/SR3, *Updated technical background to the CLEA model*. Environment Agency, Bristol.

- Department for Environment, Food and Rural Affairs (2014) SP1010: *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document*.

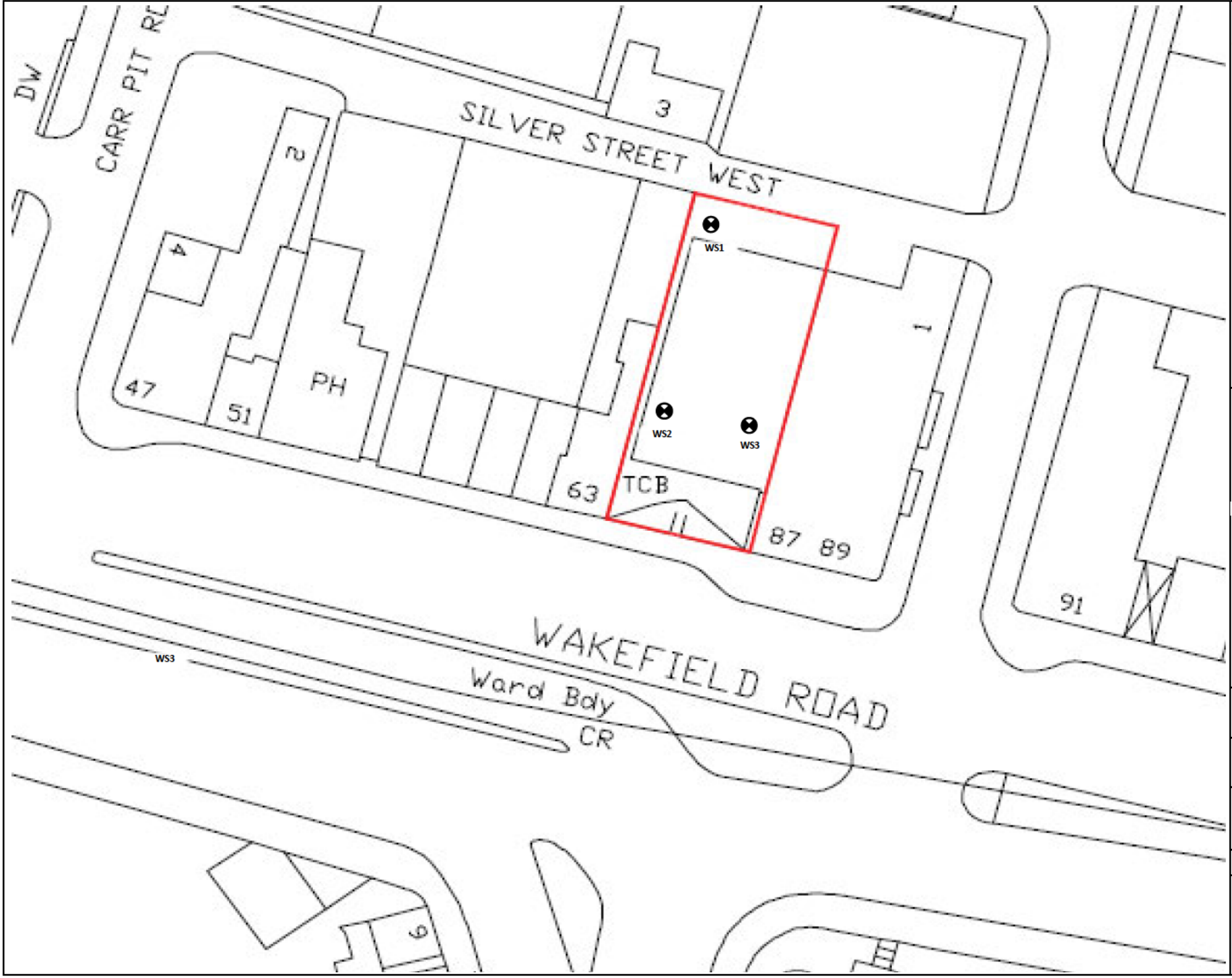
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Environmental Geotechnical Specialists

Appendix 1

Site Plan



Notes:

Investigation positions approximated from site operative's notes.

Environmental Geotechnical Specialists

RGS

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Client:

Huddersfield Taxis

Job Number:

C1570/21/E/2498

Project Details:

Wakefield Road, Huddersfield

Scale: Not to scale - reference only

Environmental Geotechnical Specialists

Appendix 2

Borehole Records

Borehole Log

Borehole No. **WS1**

Sheet 1 of 1

Project Name:	Wakefield Road, Moldgreen	Project No. C1570/21/E/2498	Co-ords:
Location:	Huddersfield		Level:
Client:	Huddersfield Taxis		Dates: 21/01/2022

Hole Type: WLS

Scale: 1:50

Logged By: IMY

Well	Water Strikes	Samples and In Situ Testing: Depth (m)	Type	Dia. (mm)	TCR (%)	Results	Depth (m)	Level (m)	Legend	Stratum Description
							0.10			CONCRETE. (Reinforced).
		0.30	ES	87	20		0.30			MADE GROUND (Dark brown slightly clayey gravelly SAND. Gravel is sub-angular to sub-rounded, fine to medium of brick, mortar and sandstone).
		1.00	SPT	77	80	N=7 (1,1/1,1,2,3)	1.00			NO RECOVERY.
		2.00	SPT	67	75	N=22 (3,4/6,5,6,5)	1.50			Soft yellowish brown mottled grey slightly gravelly silty CLAY with frequent coal specks. Gravel is sub-angular to well rounded, fine of sandstone.
		3.00	SPT			N=51 (7,9/12,15,12,12)	2.00			Light brown and greyish brown mottled, slightly clayey, locally clayey very gravelly SAND. Gravel is sub-angular to well rounded, fine to medium of sandstone. [POSSIBLE HEAD DEPOSITS].
							2.60			*1.5m - 3.45m: No clear structure present and appears reworked - possible Head deposits.*
							3.45			Medium dense brown clayey very sandy sub-angular to well rounded, fine to medium and occasional coarse GRAVEL of coarse grained sandstone and rare mudstone. [POSSIBLE HEAD DEPOSITS].
										Medium dense dark brown slightly clayey very gravelly SAND. Gravel is sub-angular to well rounded, fine to medium and occasional coarse of predominantly sandstone, occasional coal and mudstone. [POSSIBLE HEAD DEPOSITS].
										End of Borehole at 3.45m

Remarks

Borehole Log

Borehole No. **WS2**

Sheet 1 of 1

Project Name:	Wakefield Road, Moldgreen	Project No. C1570/21/E/2498	Co-ords:
Location:	Huddersfield		Level:
Client:	Huddersfield Taxis		Dates: 21/01/2022

Hole Type: WLS

Scale: 1:50

Logged By: IMY

Well	Water Strikes	Depth (m)	Type	Dia. (mm)	TCR (%)	Results	Depth (m)	Level (m)	Legend	Stratum Description
							0.15			CONCRETE (Reinforced).
		0.50	ES	87	75		0.80			MADE GROUND (Brown very sandy sub-angular to sub-rounded, fine to coarse GRAVEL of brick, sandstone and mortar with frequent partial brick and sandstone masonry fragments).
		1.00	SPT			N=4 (1,1/1,1,1,1)	1.20			MADE GROUND (Very soft brow slightly gravelly, locally very gravelly CLAY. Gravel is sub-angular to sub-rounded, fine to medium of brick, mortar and sandstone).
				77	75					
		1.70	D							Very soft yellowish brown mottled grey silty CLAY with occasional coal flecks.
		2.00	SPT			N=25 (4,5/6,6,6,7)	1.90			Medium dense dark brown slightly clayey very gravelly SAND. Gravel is sub-angular to well rounded, fine to medium and occasional coarse of predominantly sandstone, occasional coal and mudstone. [POSSIBLE HEAD DEPOSITS].
				67	80					*1.9m - 3.45m: No clear structure present and appears reworked - possible Head deposits.*
		3.00	SPT			N=52 (5,6/11,13,13,15)	3.45			End of Borehole at 3.45m

Remarks

Borehole Log

Borehole No. **WS3**

Sheet 1 of 1

Project Name:	Wakefield Road, Moldgreen	Project No. C1570/21/E/2498	Co-ords:
Location:	Huddersfield		Level:
Client:	Huddersfield Taxis		Dates: 21/02/2022

Hole Type: WLS

Scale: 1:50

Logged By: IMY

Well	Water Strikes	Samples and In Situ Testing: Depth (m)	Type	Dia. (mm)	TCR (%)	Results	Depth (m)	Level (m)	Legend	Stratum Description
							0.17			CONCRETE (Reinforced).
		0.40	ES	87	45					MADE GROUND (Brown and light brown very gravelly SAND with local clay inclusions. Gravel is sub-angular to sub-rounded, fine to coarse of brick, mortar and sandstone).
		1.00	SPT			N=7 (3,2/1,2,2,2)	0.95			Soft brown mottled grey silty CLAY with occasional coal flecks. Becomes light grey from 1.6m depth. [POSSIBLE HEAD DEPOSITS].
		1.60	D	77	95		1.70			Medium dense dark brown slightly clayey very gravelly SAND. Gravel is sub-angular to well rounded, fine to medium and occasional coarse of predominantly sandstone, occasional coal and mudstone. [POSSIBLE HEAD DEPOSITS].
		2.00	SPT			N=22 (7,3/4,6,6,6)				*1.7m - 3.45m: No clear structure present and appears reworked - possible Head deposits.*
				67	60					
		3.00	SPT			N=56 (9,11/14,13,14,15)	3.45			End of Borehole at 3.45m

Remarks

AGS

Environmental Geotechnical Specialists

Appendix 3

Laboratory Testing

Environmental
Geotechnical
Specialists

LABORATORY REPORT

job number C/1570/21/E/2498	client re
site address Wakefield Road, Moldgreen, Huddersfield, West Yorkshire, HD5 9AB	client address Acumen Designers Ltd Headrow House, Huddersfield, West Yorkshire, HD1 1SG
consultant	
date scheduled 26/01/2022	date issued 04/02/2022
issued by H J Letch	job title Technical Manager
checked by T Merry	

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ISO 9001 : 2015 REGISTERED
ISO 14001 : 2015 REGISTERED
ISO 45001 : 2018 REGISTERED
Registered Member
UKAS TESTING

GEOTECHNICAL ENVIRONMENTAL

Schedule of UKAS Accredited Laboratory Tests

1. CLASSIFICATION OF SOIL	BS 1377-2:1990	BS EN ISO 17892	Accredited (A)	Unaccredited (U)
1.1 Moisture / Water content determination				
i. Oven drying	Pt 2 : 3.2	Pt 1 : 2014	A	
ii. Saturation m/c of chalk	Pt 2 : 3.3			U
1.2 Index Properties				
i. Liquid limit – cone penetrometer	Pt 2 : 4.3	Pt 12 : 2018 : 5.3 / 5.5	A	
ii. Plastic limit	Pt 2 : 5.3		A	
iii. Shrinkage limit	Pt 2 : 6.3			U
iv. Linear shrinkage	Pt 2 : 6.5		A	
1.3 Particle Density				
i. Gas jar	Pt 2 : 8.2			U
ii. Large pyknometer	Pt 2 : 8.3			U
iii. Small pyknometer	Pt 2 : 8.4	Pt 3 : 2015 : 5.1		U
1.4 Density Tests				
i. Linear measurement	Pt 2 : 7.2	Pt 2 : 2014 : 5.1	A	
ii. Immersion in water	Pt 2 : 7.3	Pt 2 : 2014 : 5.2		U
iii. Fluid / Water displacement	Pt 2 : 7.4	Pt 2 : 2014 : 5.3		U
iv. Sand replacement	Pt 9 : 2.1, 2 2			U
v. Core cutter	Pt 9 : 2.4			U
1.5 Particle Size Distribution				
i. Dry Sieve	Pt 2 : 9.2	Pt 4 : 2016 : 5.2	A	
ii. Wet Sieve	Pt 2 : 9.3	Pt 4 : 2016 : 5.2	A	
iii. Sedimentation by pipette	Pt 2 : 9.4	Pt 4 : 2016 : 5.3 / 5.4	A	
iv. Sedimentation by hydrometer	Pt 2 : 9.5			U
2. CHEMICAL TESTS	**BS 1377-3:2018**			
ii. Mass loss on ignition	Pt 3 : 4			U
3. COMPACTION RELATED TESTS	**BS 1377-4:1990**			
3.1 Dry density/moisture relationship				
i. 2.5kg rammer – 1 litre mould	Pt 4 : 3			U
- CBR mould	Pt 4 : 3			U
ii. 4.5kg rammer – 1 litre mould	Pt 4 : 3			U
- CBR mould	Pt 4 : 3			U
3.2 Moisture Condition Value				
i. Single point test	Pt 4 : 5.4			U
ii. MCV/moisture content relationship	Pt 4 : 5.5			U
3.3 California Bearing Ratio				
i. Undisturbed sample	Pt 5 : 7			U
ii. Recompacted sample	Pt 5 : 7			U
iii. Soaked, inc measurement of swell	Pt 5 : 7			U
4. COMPRESSIBILITY OF SOIL	**BS 1377-5:1990**			
i. One dimensional consolidation	Pt 5 : 3			U
ii. Swelling pressure test	Pt 5 : 3			U
5. SHEAR STRENGTH OF SOIL	**BS 1377-7:1990**			
i. Hand shear vane	Makers instructions			U
ii. Shear box (100mm square sample)	BS 1377 : Pt 7 : 4			U
iii. Triaxial – quick undrained	BS 1377 : Pt 7 : 8, 9			U
6. PERMEABILITY				
i. Falling head	K. H. Head Vol 2			U
ii. Constant head	BS 1377 : Pt 6 : 6			U
iii Triaxial cell	BS 1377 : Pt 6 : 6			U
7. ROCK TESTS				
7.1 Classification Tests				
i. Natural moisture content	-			U
ii. Saturated moisture content	-			U
iii. Natural density	-			U
iv. Porosity	-			U
7.2 Strength Tests				
i. Point load index	ISRM '85			U
ii. Uniaxial compression test	ISRM '81			U

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Disclaimer

The results reported herein relate only to the material supplied to the laboratory.

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Summary of Classification Test Results

Project No.	Project Name
C1570/21/E/2498	Wakefield Road, Moldgreen

Hole No.	Sample				Soil Description	Density bulk / dry		w	Passing 425µm	LL	PL	PI	Particle density	Cone 80g/30° 60g/60°	Water Increase Decrease	Date
	Ref	Top	Base	Type		Mg/m3		%	%	%	%	%	Mg/m3			
WS2	2	1.70		D	Yellowish brown silty CLAY			29.0	100	65 -1pt	23	42		80g/30deg	increacing	26-Jan
WS3	2	1.60		D	Brown silty CLAY			26.0	99	51 -1pt	22	29		80g/30deg	increacing	26-Jan

All tests performed in accordance with BS EN ISO 17892 unless specified otherwise

Key			Date Printed	Approved By	Table
Density test	Liquid Limit	Particle density			1
Linear measurement unless :	4pt cone unless :	sp - small pyknometer	02/02/2022		
wd - water displacement	cas - Casagrande method	gj - gas jar			sheet
wi - immersion in water	1pt - single point test			Harry	1

Linear Shrinkage - Summary of Results

Project No.	Project Name
C1570/21/E/2498	Wakefield Road, Moldgreen

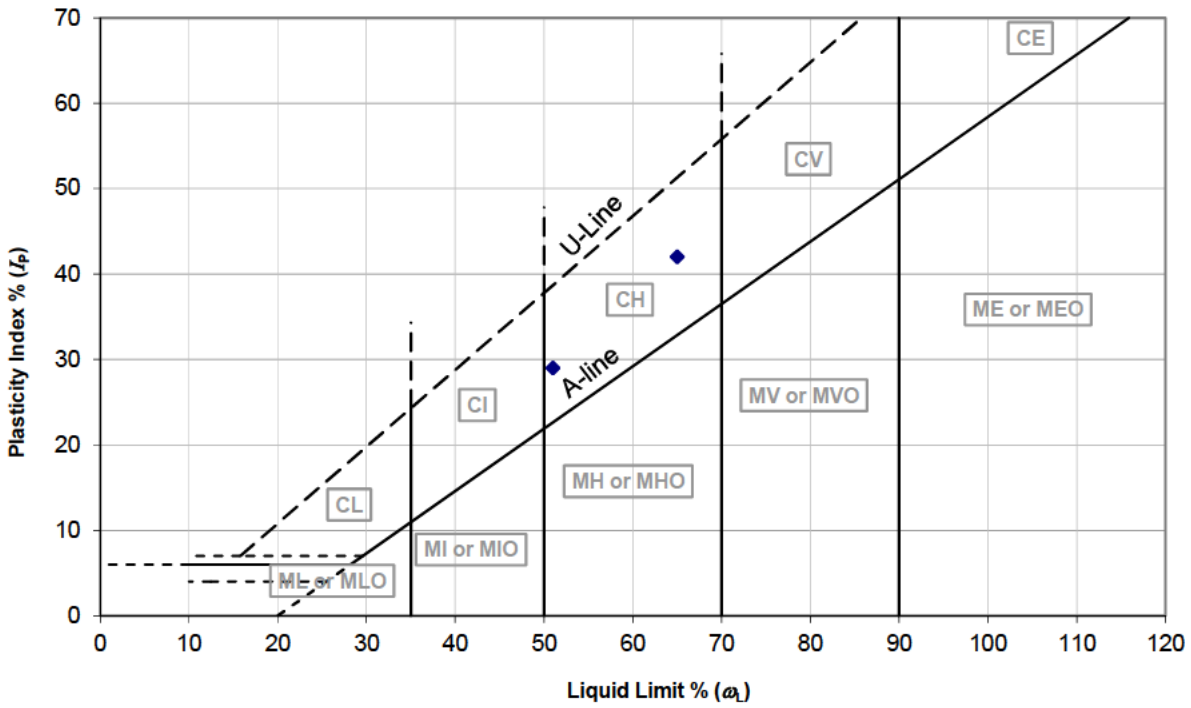
Hole No.	Sample				Soil Description	Material <425µm %	Preparation	Linear Shrinkage %	Date Tested
	Ref	Top	Base	Type					
WS2	2	1.70		D	Yellowish brown silty CLAY	100	Specimen prepared from natural material	13	31/01/2022
WS3	2	1.60		D	Brown silty CLAY	99	Specimen prepared from natural material	11	01/02/2022

Remarks:

Notes	Date Printed	Approved By	Table
Tests performed in accordance with BS 1377 : Part 2 : 1990, clause 6.5 unless annotated otherwise	02/02/2022	Harry	2
			Sheet 1

Rogers Geotechnical Services Ltd. Offices 1&2, Barncliffe Business Park, Near Bank, Shelley, Huddersfield, HD8 8LU	**Classification of Index Properties**	**C1570/21/E/2498**
Project Name: Wakefield Road, Moldgreen	**BS EN ISO: 17892: Parts 1, 12**	Fig. 3 Sheet. 1
Location: Huddersfield		Input By: Harry
Client: Huddersfield Taxis		Check By: Tobias

Location	Depth (m)	Moisture Content (w) (%)	Liquid Limit (wL) (%)	Plastic Limit (wP) (%)	Plasticity Index (IP) (%)	Retained by 0.425mm (%)	Modified (w) (w') (%)	Modified (IP) (IP') (%)	Liquidity/ Consistency (IL) (%)	Liquidity/ Consistency (IC) (%)	Casagrande Class	N.H.B.C Class (%)
WS2	1.70	28.8	65	23	42	0	29	42	0.1	0.9	C H	HIGH
WS3	1.60	26.1	51	22	29	1	26	29	0.1	0.9	C H	MEDIUM



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eurofins | Chemtest
Eurofins Chemtest Ltd
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	22-03306-1
Initial Date of Issue:	04-Feb-2022
Client	Rogers Geotechnical Services Ltd
Client Address:	Offices 1&2, Barncliffe Business Park Near Bank Shelley Huddersfield West Yorkshire HD8 8LU
Contact(s):	Harry Letch
Project	C1570/21/E/2498 Wakefield Road, Huddersfield

Quotation No.:		**Date Received:**	31-Jan-2022
Order No.:	PO-1986	**Date Instructed:**	31-Jan-2022
No. of Samples:	3		
Turnaround (Wkdays):	5	**Results Due:**	04-Feb-2022
Date Approved:	04-Feb-2022		
Approved By:			

Details:	Stuart Henderson, Technical Manager

Results - Soil

Project: C1570/21/E/2498 Wakefield Road, Huddersfield

Client: Rogers Geotechnical Services Ltd		**Chemtest Job No.:**			22-03306	22-03306	22-03306
Quotation No.:		**Chemtest Sample ID.:**			1362037	1362038	1362039
Order No.: PO-1986		Client Sample Ref.:			ES1	ES1	ES1
		Sample Location:			WS1	WS2	WS3
		Sample Type:			SOIL	SOIL	SOIL
		Top Depth (m):			0.3	0.5	0.5
		Date Sampled:			26-Jan-2022	26-Jan-2022	26-Jan-2022
		Asbestos Lab:			DURHAM	DURHAM	DURHAM
Determinand	**Accred.**	**SOP**	**Units**	**LOD**			
Cadmium	M	2450	mg/kg	0.10	0.28	0.25	0.27
Chromium (Hexavalent)	N	2490	mg/kg	0.50	< 0.50	< 0.50	< 0.50
Copper	M	2450	mg/kg	0.50	110	59	32
Mercury	M	2450	mg/kg	0.10	0.76	1.6	0.13
Nickel	M	2450	mg/kg	0.50	20	21	20
Lead	M	2450	mg/kg	0.50	450	170	81
Zinc	M	2450	mg/kg	0.50	98	170	59
Vanadium	U	2450	mg/kg	5.0	32	25	28
Arsenic	M	2450	mg/kg	1.0	35	35	9.2
Selenium	M	2450	mg/kg	0.20	0.28	0.35	0.37
Cyanide (Free)	M	2300	mg/kg	0.50	< 0.50	< 0.50	< 0.50
Total Phenols	M	2920	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Naphthalene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Fluorene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	M	2700	mg/kg	0.10	< 0.10	< 0.10	4.9
Anthracene	M	2700	mg/kg	0.10	< 0.10	< 0.10	1.1
Fluoranthene	M	2700	mg/kg	0.10	1.1	0.90	5.1
Pyrene	M	2700	mg/kg	0.10	1.0	1.1	5.4
Benzo[a]anthracene	M	2700	mg/kg	0.10	< 0.10	< 0.10	1.8
Chrysene	M	2700	mg/kg	0.10	< 0.10	< 0.10	2.1
Benzo[b]fluoranthene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	M	2700	mg/kg	2.0	2.1	2.0	20
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C8-C10	M	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C10-C12	M	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C12-C16	M	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C16-C21	M	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C21-C35	M	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0

Results - Soil

Project: C1570/21/E/2498 Wakefield Road, Huddersfield

Client: Rogers Geotechnical Services Ltd		**Chemtest Job No.:**			22-03306	22-03306	22-03306
Quotation No.:		**Chemtest Sample ID.:**			1362037	1362038	1362039
Order No.: PO-1986		Client Sample Ref.:			ES1	ES1	ES1
		Sample Location:			WS1	WS2	WS3
		Sample Type:			SOIL	SOIL	SOIL
		Top Depth (m):			0.3	0.5	0.5
		Date Sampled:			26-Jan-2022	26-Jan-2022	26-Jan-2022
		Asbestos Lab:			DURHAM	DURHAM	DURHAM
Determinand	**Accred.**	**SOP**	**Units**	**LOD**			
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0	< 5.0	< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C8-C10	M	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C10-C12	M	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C12-C16	M	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C21-C35	M	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0	< 5.0	< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0	< 10	< 10	< 10
pH	M	2010		4.0	8.8	8.7	8.5
Sulphate (2:1 Water Soluble) as SO4	M	2120	g/l	0.010	0.081	0.27	0.20
ACM Type	U	2192		N/A	-	-	-
Asbestos Identification	U	2192		N/A	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected
Moisture	N	2030	%	0.020	22	21	10
Soil Colour	N	2040		N/A	Brown	Grey	Brown
Other Material	N	2040		N/A	Stones	Stones	Stones
Soil Texture	N	2040		N/A	Sand	Clay	Sand
Sulphate (Total)	U	2430	%	0.010	0.25	0.32	0.18
Organic Matter	M	2625	%	0.40	5.0	6.9	4.0

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2040	Soil Description(Requirement of MCERTS)	Soil description	As received soil is described based upon BS5930
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2192	Asbestos	Asbestos	Polarised light microscopy / Gravimetry
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Al kaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2430	Total Sulphate in soils	Total Sulphate	Acid digestion followed by determination of sulphate in extract by ICP-OES.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2700	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-FID	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Dichloromethane extraction / GC-FID (GC-FID detection is non-selective and can be subject to interference from co-eluting compounds)
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
SOP	Standard operating procedure
LOD	Limit of detection

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 30 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

End of Report

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Appendix 4

Fill Screening Values

Rogers Geotechnical Services Ltd.

Atkins ATRISK Soil Screening Values (SSVs) - Residential Without Plant Uptake Landuse

Tox Data Report No.	Compound	Residential without Homegrown Produce Landuse (mg/kg)				Reference
	Metals	**SOM: 1%**		**SOM: 6%**		
3	Cadmium	149		149		C
4	Chromium VI	3.62	20.5	3.62	20.5	B/C
	Copper	9060		9060		A+
7	Mercury	10.00		20.30		A/D
8	Nickel	188		188		A+
	Lead	313		313		C
	Zinc	47000		47000		A+
	Vanadium	357		357		A+
	Semi and Non Metals					
1	Arsenic	39.9		37		C
10	Selenium	595		375		A
	Free Cyanide	34		34		A
9	Phenols (total)	262		1200		A
	Poly Aromatic Hydrocarbons	Free product	No free product	Free product	No free product	
20	Napthalene	0.851		13.1		A+
	Acenaphthene	156	2680	937	6730	A+
	Fluorene	124	3260	4860		A+
	Anthracene	3.48	34300	37700		A+
	Fluoranthene	4880		5050		A+
	Pyrene	3650		3780		A+
	Benzo(a)anthracene	1.71	5.42	9.04		A
2	Chrysene	0.44	852	2.64	1010	A
2	Benzo(b)fluoranthene	1.22	9.68	7.29	10.3	A
2	Benzo(k)fluoranthene	0.686	99.7	4.12	104	A
2	Benzo(a)pyrene	2.17	5.33	2.21	5.34	B/C
2	Dibenzo(a,h)anthracene	0.00393	0.949	0.0236	1.03	A*
2	Indeno(1,2,3-cd)pyrene	0.0614	9.53	0.368	10.3	A
2	Benzo(g,h,i)perylene	0.0187	102	0.112	104	A
	Petroleum Hydrocarbons					
	Aliphatic C5-C6	42.9		371		A+
	Aliphatic C6-C8	99.6		768	1240	A+
	Aliphatic C8-C10	13.9		205		A+
	Aliphatic C10-C12	49.9	81.8	297	1190	A+
	Aliphatic C12-C16	20.9	385	925	2710	A+
	Aliphatic C16-C21	212000		212000		A+
	Aliphatic C21-C35	212000		212000		A+
	Aromatic C5-C7 (Benzene)	0.31		3.32		A+
	Aromatic C7-C8 (Toluene)	312		3860		A+
	Aromatic C8-C10	22.7		332		A+
	Aromatic C10-C12	139		1550		A+
	Aromatic C12-C16	155	703	925	2710	A+
	Aromatic C16-C21	1930		1930		A+
	Aromatic C21-C35	1930		1930		A+

A+ = Values update June 2017.

A* Atrisk's SSV is lower than Chemtest's detectable limit for this compound.

B = Health Criterion Values (available from toxicological reviews published in the C4SL project methodology report).

C = Catergory 4 Screening Levels (C4SLs).

D = SSV provided is for Methyl Mercury.