

Report on a Phase 2 Geo-environmental Investigation

Location:	Land at Halifax Road, Liversedge WF15 8HE	
For:	Mr S. Nixon	
Consultants:	Studio91 Architecture	
Report No.	C2764/22/E/4214	Report date: January 2023

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

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Report Summary¹

Item	Comments	Section
Development	Erection of a new detached residential property.	1.
Geology	Superficial geology – None Solid geology – Siltstone of the Pennine Lower Coal Measures Formation.	5.
Strata Conditions	Variable thickness of topsoil and made ground. Silty gravelly clays revealed overlying weak siltstone/mudstone.	6.
Groundwater	None encountered during investigation.	6.2
Foundation Design	Strip or spread (pad) footings at about 2.0m.	10.1
Soakaways	Not recommended.	10.5
Effect of Sulphates	DC-1 concrete.	10.7
Contamination	PAH contamination revealed at some locations.	11.1
UXO Risk	Low risk.	11.3

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

1. Introduction

It is understood that the land at Halifax Road is to be developed by the construction of a single detached dwelling with a double garage. 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 Your Environment (YE) and the results were presented as report number YEX2354 in February 2022. This report has been used extensively during the current intrusive investigation.

4. Fieldworks

The fieldworks were undertaken on the 10th October 2022 and included the following:

- Four windowless sample boreholes.
- Standard penetration tests within two boreholes.
- Four dynamic probes.
- Three gas monitoring standpipes.
- Two trial pits with soakaways.

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

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, 70mm and 60mm 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 windowless sample boreholes WS01 and WS02. 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 Dynamic Probes

Dynamic penetration tests were undertaken adjacent to the windowless sample boreholes in accordance with the procedure given in BS EN ISO 22476: Part 2: 2005 +A1: 2011, using the super heavy penetrometer (DPSH). This probe consists of a 63.5kg mass falling through 750mm onto an anvil, which drives a 50mm diameter cone into the ground. The number of blows required to drive the cone through successive 100mm increments are recorded as the N_{100} values. The results of the dynamic penetration tests are tabulated and presented as bar charts of N_{100} values versus depth in Appendix 3.

4.4 Gas Monitoring Standpipes

Gas monitoring standpipes were installed between 2.25m and 3.95m depth in windowless sample boreholes WS02, WS03 and WS04, 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 at the base and above, and the installation was capped with a stop box cover in a concrete surround.

4.5 Trial Pits (Mechanical Plant)

A total of two trial pits were excavated in order to reveal the nature of the near surface soils and to undertake soakaway testing using a JCB 3CX excavator. The soils were logged on site in general accordance with BS5930: 2015+A1: 2020, and full descriptions are given on the trial pit records which are presented in Appendix 4. At regular intervals throughout the excavation of the pits, samples were taken for geotechnical testing.

Once excavations were completed, the trial pits were carefully re-instated with the arisings. Whilst every care was taken during the infilling process, including compacting of the infill at regular

intervals with the back-acting arm of the excavator, it should be appreciated that some mounding of the surface may have resulted. Moreover, the infilled soils may be subjected to settlement over time, such that a depression in the surface may also occur. Therefore, the locations of any pits undertaken in this investigation should be conveyed to the current site user, as the mounds or depressions associated with the pits may present a risk to current site operations. Furthermore, it must be realised that the infilled pits represent an area of disturbance within the site soils, thus the soils at the pit locations may vary characteristically compared to the undisturbed ground. As such, foundations placed in this disturbed material may not perform as anticipated.

4.6 Soakaways

Soakaway tests were conducted within both the trial pits excavated. At the elected test depths, the pit was trimmed and squared as much as practicable. Water was then pumped into the pit and the level monitored at timed intervals relative to a reference bar at ground level. These tests were conducted and calculated in general accordance with the method given by BRE Digest 365 and the results are presented in Appendix 5.

5. Geology

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

Strata Type	Strata Name ²	Previous Name ³	Description ³
Superficial Geology	None recorded.	-	
Solid Geology	Pennine Lower Coal Measures Formation	Lower Coal Measures	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.

6. Strata Conditions

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

Depth m below ground level to underside of layer	Strata Type	Positions Encountered	Groundwater Strikes m below ground level
0.15 – 0.50	TOPSOIL (Granular)	TP02, WS01 & WS02	None
0.05 – 0.10	ASPHALT	TP01, WS03 & WS04	None

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]

0.15 – 2.30	MADE GROUND (Granular)	All	None
1.05 – 2.10	MADE GROUND (Cohesive)	WS01, WS03 & WS04	None
1.45 – 3.10	Silty, locally gravelly sandy CLAY	TP01, TP02, WS01, WS02 & WS03	None
2.50	Clayey, silty, sandy GRAVEL	WS01	None
1.80 – +3.95	Very weak SILTSTONE	TP02, WS02 & WS03	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, topsoil and made ground were revealed to be between 0.5m and 1.05m depth. However, in WS04, the made ground was found to extend to 2.3m depth. Below the fill, predominantly firm becoming stiff, gravelly, silty clay was revealed to be between 1.5 and 3.0m over very weak siltstone.

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 WS01 and WS02 are summarised in the following table:

Strata	Depth Range (m)	SPT 'N' (Blows/300mm)		Comments
		Granular soils	Cohesive soils	
Slightly sandy, silty CLAY	0.68m to 1.46m	–	4 - 7	SPT's indicate a very soft becoming soft in-situ condition
Clayey, silty, sandy, GRAVEL	2.06m to 2.50m	19	–	SPT's indicate granular material is in a medium dense in-situ condition
Slightly sandy, slightly gravelly, silty CLAY	1.88m to 2.99m	–	16	SPT's indicate a firm becoming stiff in-situ condition
	2.50m to +3.00m	–	50+	SPT result is typical of weathered rockhead.
Mudstone/Siltstone	2.99m to 3.40m	–	15	SPT's in extremely weak rock might not be indicative of the material due to fracturing
	3.40m to +3.95m	–	50+	SPT result is typical of weathered rockhead

7.2 Dynamic Penetration Tests

Dynamic penetration tests were undertaken adjacent to the windowless sample borehole positions. A summary of the results is presented below:

Table 4: Summary of Dynamic Penetration Tests

Position	Blows/100mm			Refusal type (Effective/ Abrupt) ⁴	Comments
	0 - 2	3 - 10	10+		
	Depth to which blow count range was observed (m)				
DP1	1.8 2.0	0.2 1.9 2.8	3.1	Effective	Initial moderate results to 0.2m, followed by weak material to 2.0m. Results then gradually increased with depth.
DP2	0.1 2.2	0.3 2.9	3.9	Effective	Generally weak material to 2.2m, follow a gradual increase in blow count with depth to refusal.
DP3	0.2 0.5 0.8 1.2 2.5	0.3 0.6 1.1 1.6 3.0	3.6	Effective	Generally poor but variable to 1.6m followed by weaker material to 2.5m. Then gradual increase in results with depth.
DP4	0.6 1.0 1.4 2.6	0.3 0.8 1.3 1.5 2.8	2.86	Abrupt	Slightly stronger near surface count, followed by low blow counts to 2.8m.

7.3 Gas and Water Level Monitoring

The standpipes were monitored between the 18th October and the 04th January 2023. The results of the gas monitoring undertaken to date are tabulated below.

Table 5: Gas Monitoring

Location	Date	CH ₄ (%)	CO ₂ (%)	O ₂ (%)	Flow (l/h)	Barometric Pressure (mb)	Water Level (m)	Standpipe Depth (m)
WS02	18.10.2022	0.1	1.9	19.6	0.0	1012↑	3.14	4.1
	26.10.2022	0.0	6.0	5.9	0.1	988↓	3.06	
	01.11.2022	0.1	6.4	9.0	0.1	983↑	2.99	
	08.11.2022	0.1	8.0	6.6	0.0	975↔	3.03	
	06.12.2022	0.1	5.4	11.8	0.1	1008↔	3.12	
	04.01.2023	0.1	3.9	17.3	0.1	990↔	3.02	
WS03	18.10.2022	0.0	0.8	20.9	0.0	1012↑	3.24	3.57
	26.10.2022	0.0	2.4	17.7	0.0	988↓	3.10	
	01.11.2022	0.0	1.1	16.8	0.1	984↑	2.84	
	08.11.2022	0.1	9.9	4.4	0.0	975↔	3.25	
	06.12.2022	0.1	1.8	16.9	0.0	1009↔	3.71	
	04.01.2023	0.1	0.8	20.7	0.0	991↔	2.41	

⁴ Abrupt refusal: obstruction or bedrock encountered. Effective refusal: +25 blows/100mm.

WS04	18.10.2022	0.0	0.6	20.8	0.0	1012↑	2.19	2.28
	26.10.2022	0.0	0.9	20.0	0.0	989↓	2.11	
	01.11.2022	0.0	0.8	20.6	0.0	984↑	1.96	
	08.11.2022	0.0	0.7	20.6	0.0	975↔	2.20	
	06.12.2022	0.0	0.7	19.6	0.0	1008↔	2.18	
	04.01.2023	0.1	0.5	21.2	0.0	991↔	2.01	

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

This work was undertaken using a Geotechnical Instruments (UK) Ltd. GA5000 (serial No G503524) which was last calibrated on the 24th August 2022.

7.4 Soakaway Test

On reaching the elected soakaway test depth, the pit was trimmed and squared as much as practicable. Water was then introduced into the pit at a controlled rate to prevent collapse of the sides and the level monitored at time intervals relative to a reference bar at ground level. The results obtained from the soakaway test are presented at Appendix 5 and are summarised below:

Table 6: Soakaway Test Results					
Location	Soakage Area Dimensions (average) (m)	Depths of soaked strata (m)	Soil Description (of soaked strata)	Infiltration Rate (m/sec)	Drainage Characteristics
TP01	0.35 x 1.80	0.97 to 1.50	Side – Silty CLAY Base – As above	Not obtained	Practically Impermeable
TP02	0.40 x 1.85	1.06 to 1.85	Side – Silty CLAY Base – Siltstone	Not obtained	Practically Impermeable

During the soakaway tests the water level did not achieve a fall from 75% to 25% of the effective depth of the storage volume in the trial pit. Indeed, the water level was not observed to move for the duration of the test. On this basis, the tests could not be completed within the scope of the method provided in BRE Digest 365 due to the poor soakage rate of the exposed soils. Due to the negligible water movement it was not possible to extrapolate the results obtained in order to obtain a soil infiltration rate and as such such the strata deemed to possess practically impermeable drainage characteristics.

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 SO₄²⁻.
- Asbestos.

This testing was undertaken by Eurofins Chemtest Ltd and the results of all of the chemical testing are presented in Appendix 6 of this report.

10. Discussion of Ground Conditions - Geotechnical

It is understood that the site is to be developed by the construction of a house occupying the centre of the site surrounded by hard-standing and soft landscaped areas. 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 should be appreciated that the strata conditions within WS04 have been found to be different from the remaining investigation locations. Notwithstanding this, on the basis of the development plans, this area is to form car parking and the locations relevant to the proposed new house are WS1 to WS3 and TP1 to TP2. If development plans change or unexpected areas of deep made ground are identified within the area where the new house is to be sited, then this discussion will need to be updated.

10.1 Foundations

The results of this investigation indicate that topsoil, made ground, and soft clay will be revealed to depths of 1.7m. Such soils are not deemed suitable to represent suitable bearing strata as they are present in a weak and variable condition such that excessive total and or differential settlement could occur under moderately light loading.

It is considered that the firm to stiff residual Pennine Lower Coal Measures will provide a suitable bearing stratum, provided that the foundations are placed approx 200mm, into soil generally described as being present in at least a firm insitu condition.

Based on the strata encountered within all locations except WS04, it is considered that strip or spread foundations constructed within this material, at a minimum depth of say 2.0m, could be designed assuming an allowable increase in stress given in the following table:

Table 9: Allowable Increase in Stress

Foundation Type		Strip Footings			Spread/Pad Footings		
		Foundation Breadth	B (m)	0.6	1.0	1.5	1.0
Foundation Depth	D (m)	2.0			2.0		
Allowable Increase in Stress	(kN/m ²)	145	140	130	165	155	150
Net Allowable Bearing Capacity ⁶	(kN/m ²)	185	180	170	205	195	190

The allowable increase in stress given above assumes a factor of safety of 3 against general shear failure, with cohesion of 60kN/m² at the foundation depths. Settlements at the above loading intensities should remain within tolerable limits for the type of structure proposed provided that the underlying soils are carefully inspected immediately once 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.

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.

The stability of the 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.

10.2 Volume Change Potential

It should be appreciated that the cohesive soils revealed at this site possess a predominantly medium volume change potential under the guidance of the NHBC standards. Therefore, it is will be necessary to ensure that the depths of the foundations are designed in accordance with the Chapter 4.2 of the NHBC standards⁷. 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. This may result in foundation depths greater than those given above and the requirement for heave protection to be employed against footings and below the underside of the floors and beams.

10.3 General Comments for Excavations

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.

⁶ Assumes bulk density of material removed from footing excavations to be 20kN/m³

⁷ NHBC Standards, Chapter 4.2, *Building near trees*

Should the excavations be required to stand open, it is considered that a blinding layer of lean-mixed concrete be placed over the sub-grade. This expedient will reduce loosening or softening of the underlying soil due to both physical disturbance and the ingress of surface water.

Should seepage of groundwater be encountered it is considered that it 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.

10.4 Ground-floors

In light of the made ground and weak near surface soils, 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.

Further to the above, due to the volume change potential at the site, should the floor be placed within the zone of influence of any existing, or proposed, trees and shrubs, an allowance for soil volume change should be included. Further guidance is available in the NHBC standards; however, soil volume change can typically be catered for by providing a suitable void or utilize proprietary materials beneath the floor slab.

10.5 Soakaways

The results of the testing have revealed practically impermeable drainage conditions. Therefore, the use of soakaways cannot be recommended and alternative methods of drainage should be sought.

10.6 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 <4% could be employed in the pavement design⁸. 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.

10.7 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 C2⁹, 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 concrete should be designed in accordance with Class DS-1 requirements. Assuming static groundwater, the table also indicates that the aggressive chemical environment for concrete (ACEC) classification is AC-1s.

⁸ Table 11.1, *Reproduction of TRRL Report LR1132 (1984)*, Smith (2006), Smith's Elements of Soil Mechanics, 8th ed.

⁹ Table C2, *Aggressive Chemical Environment for Concrete (ACEC) classification for brownfield locations*

In order to evaluate the design chemical (DC) class for the buried concrete at this site reference should be made to Table D1¹⁰, 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 construction of a single residential property with hard-standing and soft landscaped areas. Consequently, the site may be classified as residential with 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 4.3% and 16.0%. On this basis, it is considered that the screening values associated with 6% 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 website¹¹ 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 6. These results indicate the following:

Table 10: Summary of Contaminated Areas

Location	Depth (m)	Contaminants found to be exceeding SSVs (Residential with plant uptake)
WS01	0.25	PAHs [Chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, benzo(g,h,i)perylene]
WS02	0.50	PAHs [Benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, benzo(g,h,i)perylene]
WS04	0.50	None

Concentrations of chromium^{VI}, free cyanide, phenols (total), total petroleum hydrocarbons (aliphatic C6 to C7, C8 to C12 and C35 to C40; aromatic C5 to C8 and C10 to C12), benzene, toluene, ethylbenzene, m & p-xylene, o-xylene and methyl tert-butyl ether 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

¹⁰ 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.*

¹¹ <http://www.atrisksoil.co.uk/pages/general/subscribers.asp>

total exposure, which is unlikely to significantly affect the combined assessment criterion¹². 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 11: Summary of Areas Contaminated by PAHs & TPHs		
Location	Depth (m)	Contaminants found to be exceeding SSVs (Residential with Plant Uptake)
WS01	0.25	PAHs [Benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene]
WS02	0.50	PAHs [Benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene]
WS04	0.50	None

On the basis of the above information, the results of the investigation have concluded that the site is generally contaminated by PAHs.

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 0.5% and 9.9%, in association with oxygen levels of between 4.4% and 21.2%. 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 975mb and 1012mb and so it is expected that the site has been observed in these conditions.

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 9.9% (0.099) 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 0.0099 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 2* as the level of CO₂ is over 5%. It is therefore considered that there is a risk of harm to end users and site operatives and as such, special precautionary measures are required in accordance to Table 8.6, *Typical scope of gas protection measures*, of CIRIA report C665.

With regard to the number of monitoring visits required reference is made to Tables 5.5a and 5.5b of CIRIA report C665 (2007)¹³. Accepting that the proposed development is of high sensitivity and that

¹² Ref: ATRISK soil, SSVs derived using CLEA v1.071 for 6% SOM, Residential with home grown produce land use, 23.06.17.

¹³ Adapted from tables 5.5a and 5.5b of CIRIA C665, 2007, *Assessing risks posed by hazardous ground gas to buildings*, p60.

the generation potential is very low, these tables suggest that 6 readings could be undertaken over a period of 3 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 6 monitoring visits were undertaken over a 3-month time period and for the purpose of this assessment, it is considered that the site can be fully classified as Characteristic Situation Level 2.

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 Agency¹⁴ advice on the assessment of risks arising from the presence of contamination in soils and using the source-pathway-receptor approach.¹⁵ 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.'¹⁶

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 12. Sources of contamination include the following:

On-site – Topsoil and Made Ground (PAHs).

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

¹⁴ 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'.

¹⁵ 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.

¹⁶ See 'Circular 2/2000 Contaminated Land: Implementation of Part II of The Environmental Protection Act 1990', appendix A.

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 12.



Table 12: Conceptual Site Model and Site-Specific Risk Assessment [Contamination: PAHs]

Conceptual Site Model			Site Specific Risk Assessment	
Pathways	Receptor	Linkage Present?	Risk Rating	Notes
Direct contact/dermal absorption/soil ingestion	Operative	Yes – contamination found to be present at the site and contact with soil likely during works.	High	Some 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 – contamination found to be present at the site and site to be developed into a residential property with landscaped areas.	High	
	Neighbours	Yes – 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. In addition, some PAH contamination found is likely to represent a significant vapour risk.	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. In addition, some PAH contamination found is likely to represent a significant vapour risk.	High	
	Neighbours	Yes – contamination found to be present at the site and residential and commercial properties located within 250m radius of the site and possible inhalation of dust during the works.	High	
Ingestion of fruit/vegetables and/or waters	Operative	No – no edible 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 likelihood 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 a residential property with landscaped areas.	High	
	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 – elevated concentrations of carbon dioxide have been found to be present at the site (assuming <i>Characteristic Situation Level 2</i>).	Low	Elevated concentrations of carbon dioxide were detected at the site. Therefore, special precautionary measures are deemed to be required. Remediation will be required to either remove the contamination or break pathways.
	End User		Low	



	Neighbours	No – whilst concentrations of ground gas have been found to be present at the site (<i>Characteristic Situation Level 2</i>), no structures directly adjoin the site, therefore gases migrating from the site would vent to atmosphere before reaching neighbouring structures.	N/A	
Spillage/loss/run off direct to receiving water	Controlled Waters	Yes – contaminated by PAHs. However, the site is underlain by cohesive soils of low permeability and no controlled waters within 250m.	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 – a Secondary A aquifer is present beneath the site. However, the site is underlain by cohesive soils of practically impermeable permeability.	Low	
Run off via drainage/sewers etc	Controlled Waters	Yes – old services may be present on site.	Moderate	
Direct contact with contaminated soils	Plants	Yes – significant 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 – PAH contamination revealed at the site may represent a significant risk to building materials or plastic water pipes. Moreover, testing indicates that the aggressive chemical environment for concrete classification is AC-1s.	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	Yes – Site is located in an area where 1% to 3% of properties may be at or above the action level.	Low	No radon protection measures required.
	End User			
UXO Risk	Operative	No – Zetica online maps indicate that the site is within a low risk area for UXO.	Low	No further action required.
	End User		Low	

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 and vapours.
- To protect the end user from the elevated levels of carbon dioxide.
- 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 reach controlled waters via surface run-off or permeable strata.
- 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 or groundwaters.

11.3.2 Development Requirements

Whilst the precise nature of this development has not been finalised it is understood that it is to be developed by the construction of a new residential property with hard-standing and 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.

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 and the hazards of working in areas where accumulations of carbon dioxide could occur.
- 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.
- Undertake risk assessments in relation to the presence of high levels of PAHs within parts of site and ensure appropriate PPE is provided or protection measures undertaken where necessary, particularly if workers are to enter confined spaces and excavations during construction.

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.

Landscaped Areas

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.

Gas Protection Measures

In order to assess the protection measures required BS8485: 2015+A1:2019: *Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings* has been employed. In accordance with Table 3, *Building types*, of the code, the development may be considered to conform to Type A. Therefore, on the basis of Table 4 *Gas protection score by CS and type of building*, the minimum gas protection score (points) is 3.5. The gas protection system should consist of at least two different elements that add up to 3.5. The elements work independently and collaboratively, and a single element should not be used because there would be no redundancy to allow for defects in the component.

In order to achieve this score, the following shall be undertaken.

Table 13: Combination of protection elements (BS8485: 2015) for CS2		
Reference	Protection Element	Score
Table 5	Precast suspended segmental subfloor (i.e. beam and block) on the basis of the geotechnical discussion	0
Table 6	Passive sub-floor dispersal layer: very good or good performance (Note 1) (see Annex B of the Code for detail)	1.5 Good 2.5 Very Good
Table 7	Gas resistant membrane complying with the requirements given in Table 7 (Note 2)	2
		Total Score
		Min: 3.5 Max: 4.5

Note 1:

As a suspended floor is assumed to be utilised at this site, based on geotechnical considerations, it is considered that a clear void with air bricks in the external walls be utilised. The details of the system to be adopted shall be included on the technical drawings provided by the engineer/architect.

Note 2:

The gas resistant membrane shall meet the following criteria:

- Sufficiently impervious (methane gas transmission rate <40.0ml/day/m²/atm (average) BS ISO 15105-1 manometric method).
- Sufficiently durable and strong to remain serviceable for the anticipated life of the building, to withstand in-service stresses and installation process.
- Capable, after installation, of providing a complete barrier to the entry of the relevant gas.
- Verified in accordance with CIRIA C735: 2014: *Good practice on the testing and verification of protection systems of buildings against hazardous ground gasses.*

In addition to the above, the following points shall be considered.

- Technical drawings of the incorporation of the gas protection measures into the sub-structure will be provided by a suitably qualified engineer/architect and produced in accordance with the guidance given in BRE 414.
- The sequence of construction indicating when the gas protection system will be installed will be included with the remediation statement. Where possible the installation of membranes will take place as a unique activity on site and shall not take place until sub-structure construction is complete.
- During and following the installation of the membrane, all parties in attendance at the site shall be made aware that a gas protection system is to be employed within the construction. Such communications should include, but not be limited to, the CDM documentation for the site and site inductions.
- The installation of the membrane shall be carried out only by suitable personnel and the qualifications or experience/training will be included as part of the remediation statement. The suitability of personnel will be assessed in accordance with Annex 1 of CIRIA C735.
- The installation shall be in strict accordance with manufacturer specifications and recommendations, which shall also be included as part of the remediation statement.
- The membrane system employed will not be an ensemble (i.e. a system comprising a mixture of products from different manufacturers will not be employed).
- Membranes shall be supplied to site on a single wound roll, creased product will not be accepted or employed.
- Whilst membranes are exposed, signage will be provided to indicate the access to the installation area is prohibited unless authorised. Footwear will be checked prior to accessing the membrane surface to ensure no sharp objects are apparent, such as stones caught in treads. The use of sharp objects or hot-works around the exposed membrane will be strictly prohibited unless the risk of damaging the membrane has been full assessed and mitigated.
- Non-conformance of manufacturer recommendations shall be discussed and agreed as acceptable, in writing, with a suitably qualified person from the manufacturer.

Verification of the installation of the gas protection system will be carried out as per agreement with any statutory authorities prior to construction.

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 YALPAG¹⁷ documentation and may be used as

¹⁷ YALPAG *Technical Guidance for Developers, Landowners and Consultants – Verification Requirements for Cover Systems V4 .1 Appendix 1a*, June 2021

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).

Table 14: 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 500m ³	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 50m ³ and 1 per 250m ³	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 50m ³ and 1 per 100m ³	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 15: Fill Screening Values

Contaminant	Screening Value (Residential with Plant Uptake) (mg/kg)		Reference
	1% SOM	6% SOM	
As	37	37	Atrisk ^{SOIL} SSVs
Cd	22.1	22.1	Atrisk ^{SOIL} SSVs
Cr(VI)	3.62	3.63	Atrisk ^{SOIL} SSVs
Cu	4730	4790	Atrisk ^{SOIL} SSVs
Hg	8.81	15.8	Atrisk ^{SOIL} SSVs
Ni	136	136	Atrisk ^{SOIL} SSVs
Pb	200	200	Atrisk ^{SOIL} SSVs
V	136	138	Atrisk ^{SOIL} SSVs
Zn	20000	20300	Atrisk ^{SOIL} SSVs

Please see summary sheet within Appendix 7 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.

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:

- The assessment of the extents of any contamination 'hot-spots' identified including the details of sampling points, such as location and descriptive logs, and the results of any chemical testing.
- 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.
- Evidence that gas protection measures have been implemented and installed in accordance with manufacturer's instructions. The evidence should also demonstrate that all joints and penetrations have been adequately sealed. The verification should be undertaken by a suitably qualified specialist. This may not be required should all areas of TPH contamination be removed during the ground-works phase.

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.
- 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.
- Discussions with contractors in relation to the suitability of materials and installation methods for gas barriers, if required.
- Produce a validation report to demonstrate that the geo-environmental risks discussed in this report have been mitigated.
- Detailed design of the sub-structure.
- Complete in-situ CBR testing to determine appropriate design values for vehicle parking areas.

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

13. References

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Appendix 1

Site Plan



Notes:

Investigation positions approximated from site operative's notes.



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Client:
Studio91 Architecture

Job Number:
C2764/22/E/4214

Project Details:
Land at Halifax Road, Liversedge

Scale: Not to scale - reference only





Appendix 2

Borehole Records



Borehole Log

Borehole No.
WS01
Sheet 1 of 1
Hole Type
WLS
Scale
1:25
Logged By
TM

Project Name: Land at Halifax Road, Liversedge
Project No. C2764/22/E/4214
Co-ords:
Location: Land at Halifax Road, Liversedge, West Yorkshire, WF15 8HE
Level:
Client: Studio91 Architecture
Dates: 10/10/2022

Well	Water Strikes	Samples and In Situ Testing				Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Dia. (mm)	TCR (%)					
								TOPSOIL (Loose, dark brown, silty, very gravelly fine to coarse SAND. Gravel is angular to sub-rounded and fine to medium of various lithologies and brick).		
		0.80	D	90	95	0.45		MADE GROUND (Soft, dark brown, slightly sandy, silty CLAY. Sand is fine to coarse). [Reworked natural material]		
		1.00	SPT			1.05		Very soft to soft, dark brown mottled brown, silty CLAY. RESIDUAL PENNINE LOWER COAL MEASURES FORMATION	1	
		1.50	D	80	90	1.45		Stiff, brown, slightly sandy, slightly gravelly, silty CLAY. Sand is fine to coarse. Gravel is angular to sub-angular and fine of siltstone. RESIDUAL PENNINE LOWER COAL MEASURES FORMATION		
		2.00	SPT			2.05		Medium dense, greyish brown, clayey, silty, sandy angular to sub-angular and fine to medium GRAVEL of weak siltstone. Sand is fine to coarse. RESIDUAL PENNINE LOWER COAL MEASURES FORMATION	2	
		3.00	SPT	70	95	2.50		Stiff, brown, slightly sandy, slightly gravelly, silty CLAY. Sand is fine to coarse. Gravel is angular to sub-angular and fine and of weak siltstone. Sand is fine to coarse. RESIDUAL PENNINE LOWER COAL MEASURES FORMATION	3	
						3.00		End of Borehole at 3.00m	3	
									4	
									5	

Remarks





Borehole Log

Borehole No.

WS02

Sheet 1 of 1

Project Name:	Land at Halifax Road, Liversedge	Project No.	C2764/22/E/4214	Co-ords:		Hole Type	WLS
Location:	Land at Halifax Road, Liversedge, West Yorkshire, WF15 8HE			Level:		Scale	1:25
Client:	Studio91 Architecture			Dates:	10/10/2022	Logged By	TM

Well	Water Strikes	Samples and In Situ Testing				Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Dia. (mm)	TCR (%)				
								<p>0.15</p> <p>TOPSOIL (Loose, dark brown, silty, very gravelly, fine to coarse SAND. Gravel is angular to sub-rounded and fine to medium of various lithologies).</p>	
				90	100			<p>0.55</p> <p>MADE GROUND (Loose, dark brown to reddish brown, silty, sandy angular to sub-rounded and fine to coarse GRAVEL of various lithologies and brick. Sand is fine to coarse).</p>	
								<p>0.70</p> <p>Soft, dark brown, slightly sandy, silty CLAY. Sand is fine to coarse.</p>	
		1.00	D					<p>RESIDUAL PENNINE LOWER COAL MEASURES FORMATION</p>	
		1.00	SPT			N=7 (1,1/1,1,2,3)			
				80	90			<p>1.35</p> <p>Firm, light brown, slightly sandy, silty CLAY. Sand is fine to coarse.</p>	
								<p>1.90</p> <p>Firm to stiff, dark brown, slightly sandy, locally slightly gravelly, silty CLAY. Sand is fine to coarse becoming fine. Gravel is angular to sub-angular and fine to medium of siltstone.</p>	
		2.00	SPT			N=16 (2,2/3,3,5,5)		<p>RESIDUAL PENNINE LOWER COAL MEASURES FORMATION</p>	
				70	90				
								<p>2.30</p> <p>Firm, very dark brown, slightly sandy, slightly gravelly, silty CLAY. Sand is fine to coarse. Gravel is angular to sub-angular and fine to medium of siltstone.</p>	
								<p>3.00</p> <p>Stiff, brown, slightly sandy, slightly gravelly, silty CLAY. Sand is fine to coarse. Gravel is angular to sub-angular and fine to medium of siltstone.</p>	
		3.00	SPT			N=15 (3,4/4,3,4,4)		<p>RESIDUAL PENNINE LOWER COAL MEASURES FORMATION</p>	
				60	95				
								<p>3.40</p> <p>Very weak, thinly laminated, greyish brown SILTSTONE recovered as medium dense, greyish brown, tabular, very angular to sub-angular and fine to coarse gravel of siltstone</p>	
								<p>3.95</p> <p>Very weak, thickly laminated, greyish brown SILTSTONE recovered as medium dense, greyish brown, tabular, very angular to sub-angular and fine to coarse gravel of siltstone.</p>	
		3.95	SPT			27 (10,16/27 for 35mm)		<p>PENNINE LOWER COAL MEASURES FORMATION</p> <p>End of Borehole at 3.95m</p>	

Remarks





Borehole Log

Borehole No.

WS03

Sheet 1 of 1

Project Name:	Land at Halifax Road, Liversedge	Project No.	C2764/22/E/4214	Co-ords:		Hole Type	WLS
Location:	Land at Halifax Road, Liversedge, West Yorkshire, WF15 8HE			Level:		Scale	1:25
Client:	Studio91 Architecture			Dates:	10/10/2022	Logged By	TM

Well	Water Strikes	Samples and In Situ Testing				Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Dia. (mm)	TCR (%)					
								ASPHALT.		
				90	95	0.10		MADE GROUND (Loose becoming dense, multicoloured, slightly silty, sandy angular to sub-rounded and fine to medium GRAVEL of various lithologies, brick and concrete. Sand is fine to coarse).		
						0.40				
						0.75		MADE GROUND (Dense becoming medium dense, yellowish brown, slightly silty, sandy sub-angular to sub-rounded and fine to coarse GRAVEL of sandstone. Sand is fine to coarse).		
		1.20	D					MADE GROUND (Firm becoming very soft, dark brown, slightly sandy, gravelly, silty CLAY. Sand is fine to coarse. Gravel is and angular to sub-rounded and fine to coarse becoming medium of sandstone).	1	
				80	90	1.50		Soft becoming firm, brown to grey, thinly laminated, silty CLAY. RESIDUAL PENNINE LOWER COAL MEASURES FORMATION		
		1.80	D							2
				70	100	2.45		Stiff, brown laminated grey becoming very dark brownish grey to grey, slightly sandy, slightly gravelly, silty CLAY. Sand is fine to coarse. Gravel is angular to sub-angular and fine to medium of very weak siltstone. RESIDUAL PENNINE LOWER COAL MEASURES FORMATION		
						3.10				3
				60	80	3.60		Very weak, thinly to thickly laminated, greyish brown SILTSTONE recovered as medium dense, greyish brown, very angular to sub-angular and fine to coarse gravel of siltstone. PENNINE LOWER COAL MEASURES FORMATION		
								End of Borehole at 3.60m	4	
									5	

Remarks





Borehole Log

Borehole No.

WS04

Sheet 1 of 1

Project Name:	Land at Halifax Road, Liversedge	Project No.	C2764/22/E/4214	Co-ords:		Hole Type	WLS
Location:	Land at Halifax Road, Liversedge, West Yorkshire, WF15 8HE			Level:		Scale	1:25
Client:	Studio91 Architecture			Dates:	10/10/2022	Logged By	TM

Well	Water Strikes	Samples and In Situ Testing				Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Dia. (mm)	TCR (%)				
Well	Water Strikes					0.10			ASPHALT.
				90	90				MADE GROUND (Loose, grey and dark brown locally reddish brown and yellowish brown, slightly clayey, slightly silty, sandy angular to sub-angular and fine to coarse GRAVEL of sandstone, brick and asphalt. Sand is fine to coarse).
						0.80			MADE GROUND (Firm, dark brown, slightly sandy, gravelly, silty CLAY. Sand is fine to coarse. Gravel is angular to sub-rounded and fine to medium of sandstone and asphalt).
				80	95				MADE GROUND (Loose, reddish brown to orangish-yellowish brown, silty, slightly sandy becoming sandy angular to sub-rounded and fine to coarse GRAVEL of sandstone and localised brick. Sand is fine to coarse).
						1.80			MADE GROUND (Soft, yellowish brown, slightly sandy, gravelly, silty CLAY. Sand is fine to coarse. Gravel is angular to sub-rounded and fine to coarse of sandstone and brick).
				70	80	2.10			MADE GROUND (Loose, dark brown, slightly silty, sandy sub-angular to sub rounded and fine to coarse GRAVEL of sandstone, brick and quartzite. Sand is fine to coarse).
						2.30			End of Borehole at 2.30m

Remarks



Appendix 3

Dynamic Probing Records



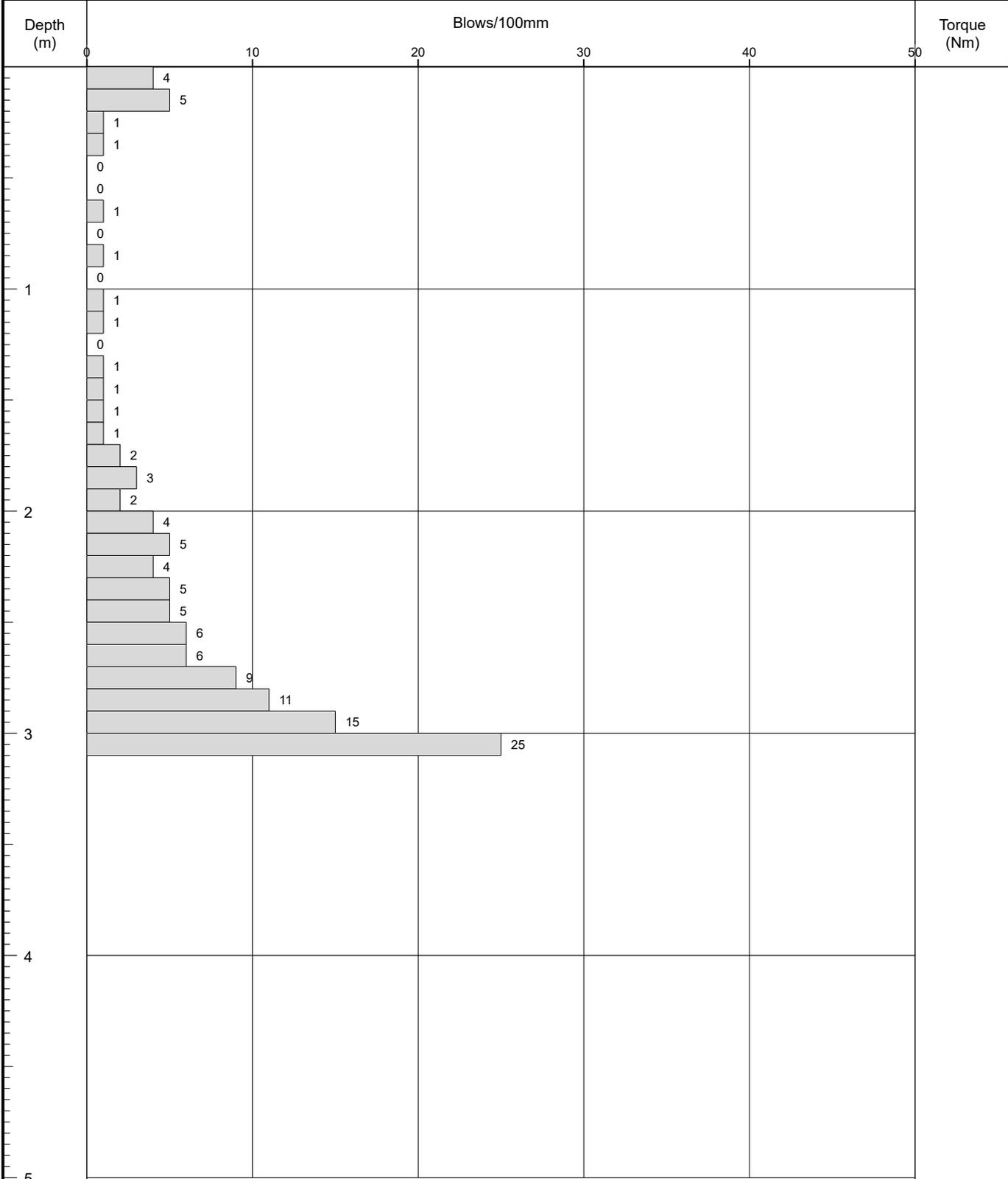
Probe Log

Probe No.

DCP01

Sheet 1 of 1

Project Name: Land at Halifax Road, Liversedge	Project No. C2764/22/E/4214	Co-ords:	Hole Type DCP
Location: Land at Halifax Road, Liversedge, West Yorkshire, WF15 8HE	Level:		Scale 1:25
Client: Studio91 Architecture	Dates: 10/10/2022		Logged By RMc



Remarks: Effective refusal	Fall Height	750mm	Cone Base Diameter	50.5mm
	Hammer Wt	63.5kg	Final Depth	3.1m
	Probe Type	DPSH-B		





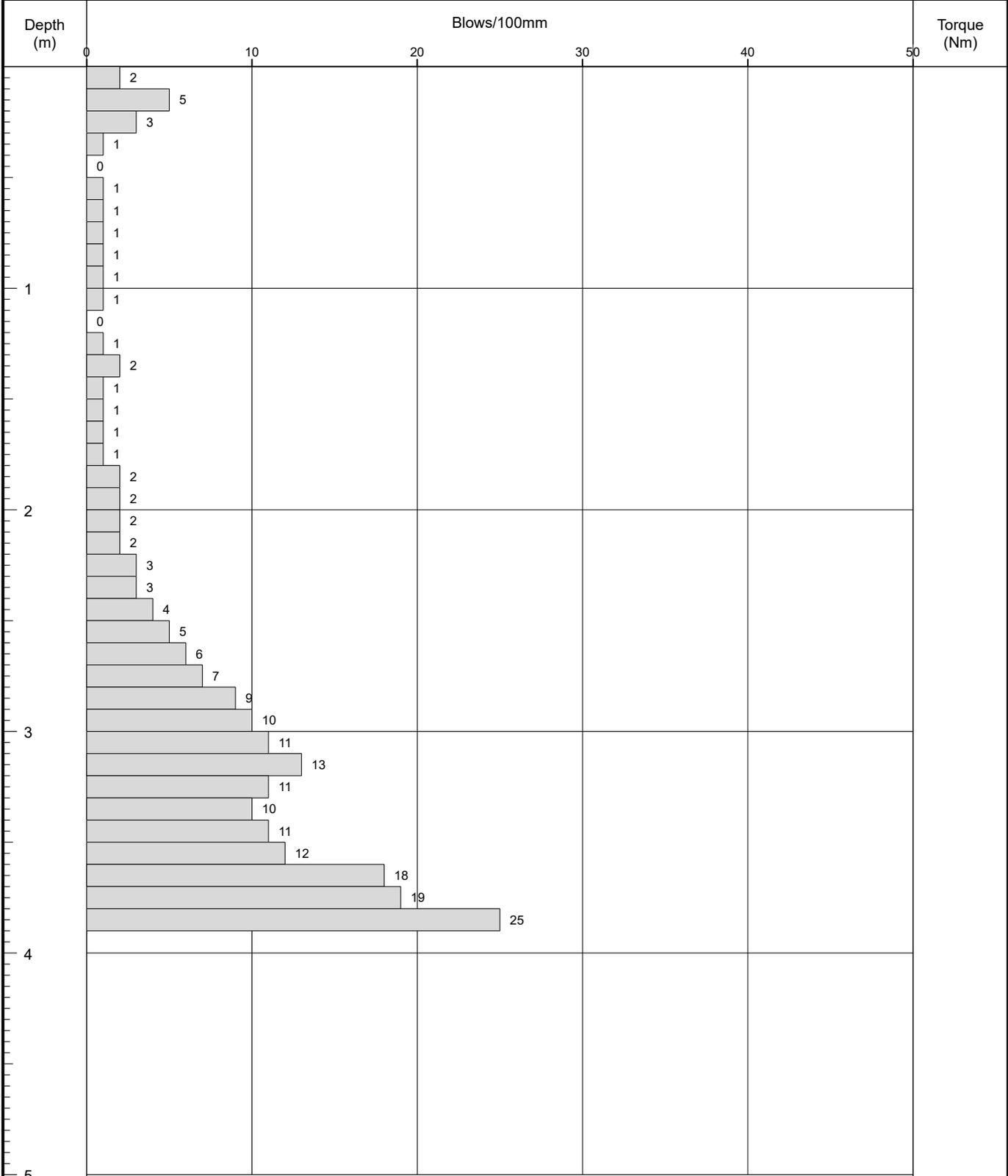
Probe Log

Probe No.

DCP02

Sheet 1 of 1

Project Name: Land at Halifax Road, Liversedge	Project No. C2764/22/E/4214	Co-ords:	Hole Type DCP
Location: Land at Halifax Road, Liversedge, West Yorkshire, WF15 8HE	Level:		Scale 1:25
Client: Studio91 Architecture	Dates: 10/10/2022		Logged By RMc



Remarks: Effective refusal	Fall Height	750mm	Cone Base Diameter	50.5mm
	Hammer Wt	63.5kg	Final Depth	3.9m
	Probe Type	DPSH-B		





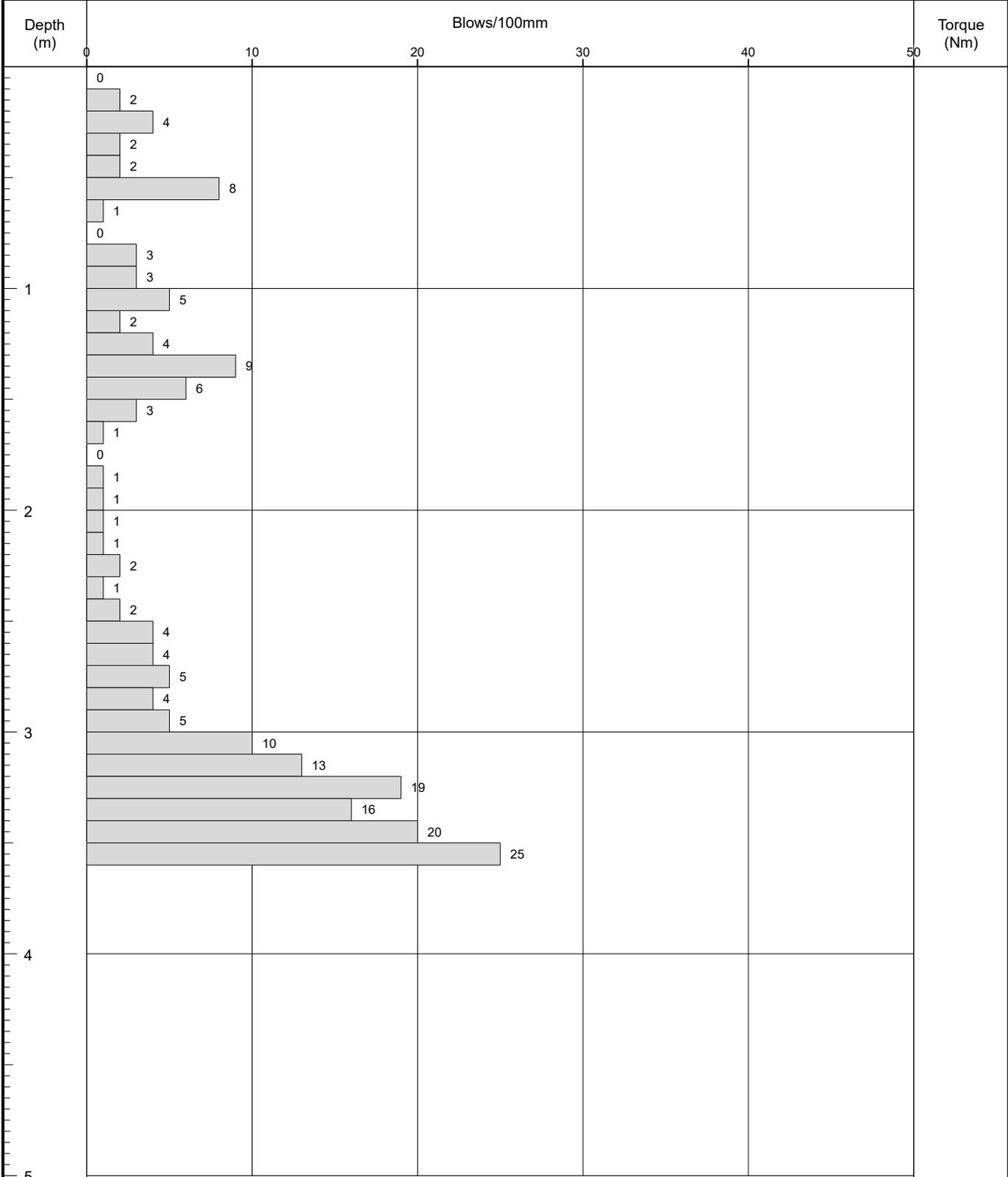
Probe Log

Probe No.

DCP03

Sheet 1 of 1

Project Name: Land at Halifax Road, Liversedge	Project No. C2764/22/E/4214	Co-ords:	Hole Type DCP
Location: Land at Halifax Road, Liversedge, West Yorkshire, WF15 8HE	Level:		Scale 1:25
Client: Studio91 Architecture	Dates: 10/10/2022		Logged By RMc



Remarks: Effective refusal	Fall Height	750mm	Cone Base Diameter	50.5mm
	Hammer Wt	63.5kg	Final Depth	3.6m
	Probe Type	DPSH-B		





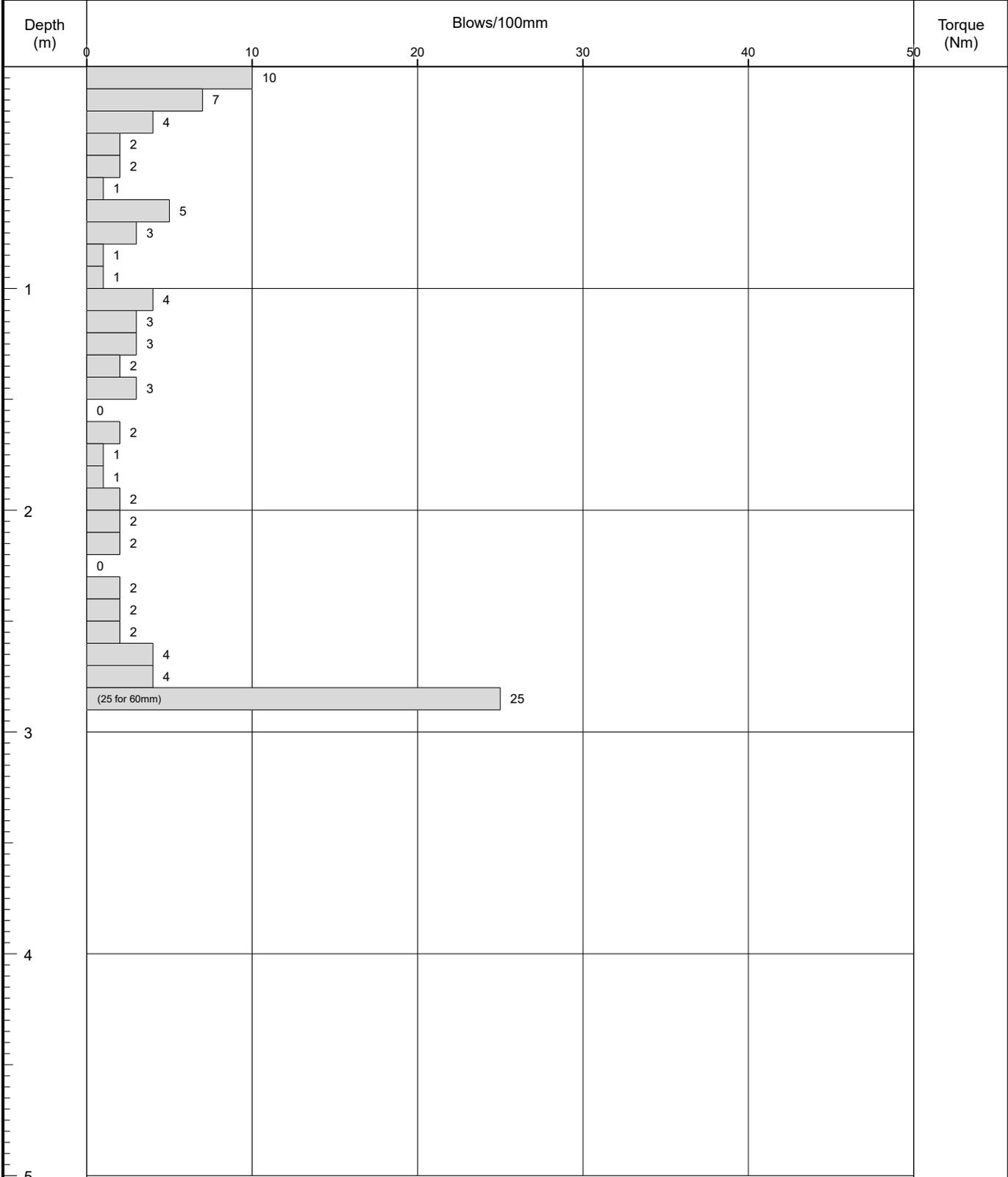
Probe Log

Probe No.

DCP04

Sheet 1 of 1

Project Name: Land at Halifax Road, Liversedge	Project No. C2764/22/E/4214	Co-ords:	Hole Type DCP
Location: Land at Halifax Road, Liversedge, West Yorkshire, WF15 8HE	Level:		Scale 1:25
Client: Studio91 Architecture	Dates: 10/10/2022		Logged By RMc



Remarks: Effective refusal	Fall Height	750mm	Cone Base Diameter	50.5mm
	Hammer Wt	63.5kg	Final Depth	2.86m
	Probe Type	DPSH-B		





Appendix 4

Trial Pit Records



Trial Pit Log

Trialpit No
TP01
Sheet 1 of 1

Project Name: Land at Halifax Road, Liversedge Project No. C2764/22/E/4214 Co-ords: - Date 10/10/2022
Level: Level:

Location: Land at Halifax Road, Liversedge, West Yorkshire, WF15 8HE Dimensions (m): 1.8
Client: Studio91 Architecture Depth 0.35 Logged TM
1.50

Water Strike	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth	Type	Results				
	0.05 - 0.35	B		0.05			ASPHALT. MADE GROUND (Dark brown, slightly silty, sandy angular to sub-angular and fine to coarse GRAVEL of sandstone and siltstone. Sand is fine to coarse).
	0.35 - 0.70	B		0.35			MADE GROUND (Dark brown, slightly silty, sandy angular to sub-angular and fine to coarse GRAVEL of sandstone and brick, with low cobble content. Sand is fine to coarse. Cobbles are angular to sub-angular of <150mm of sandstone and brick).
	0.70 - 1.00	B		0.70			Stiff, orangish brown mottled grey, silty CLAY. PENNINE LOWER COAL MEASURES FORMATION
				1.50			End of pit at 1.50 m

Remarks:

Stability: Stable





Trial Pit Log

Trialpit No
TP02
Sheet 1 of 1

Project Name: Land at Halifax Road, Liversedge Project No. C2764/22/E/4214 Co-ords: - Date 10/10/2022
Level: Level:

Location: Land at Halifax Road, Liversedge, West Yorkshire, WF15 8HE Dimensions (m): 2.1
Client: Studio91 Architecture Depth 1.85 0.4 Scale 1:25
Logged TM

Water Strike	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth	Type	Results				
	0.00 - 0.50	B					TOPSOIL (Dark brown, slightly clayey, very silty, gravelly fine to coarse SAND. Gravel is angular to sub-rounded and fine to medium of sandstone, siltstone and glass).
	0.50 - 1.00	B		0.50			Firm, grey mottled orangish brown, silty CLAY. PENNINE LOWER COAL MEASURES FORMATION
	1.70 - 1.80	B		1.70 1.80			Very weak, thinly laminated, brownish grey, SILTSTONE recovered as brownish grey, tabular, very angular to sub-angular and fine to coarse gravel of siltstone. PENNINE LOWER COAL MEASURES FORMATION End of pit at 1.85 m

Remarks:

Stability: Stable



Appendix 5

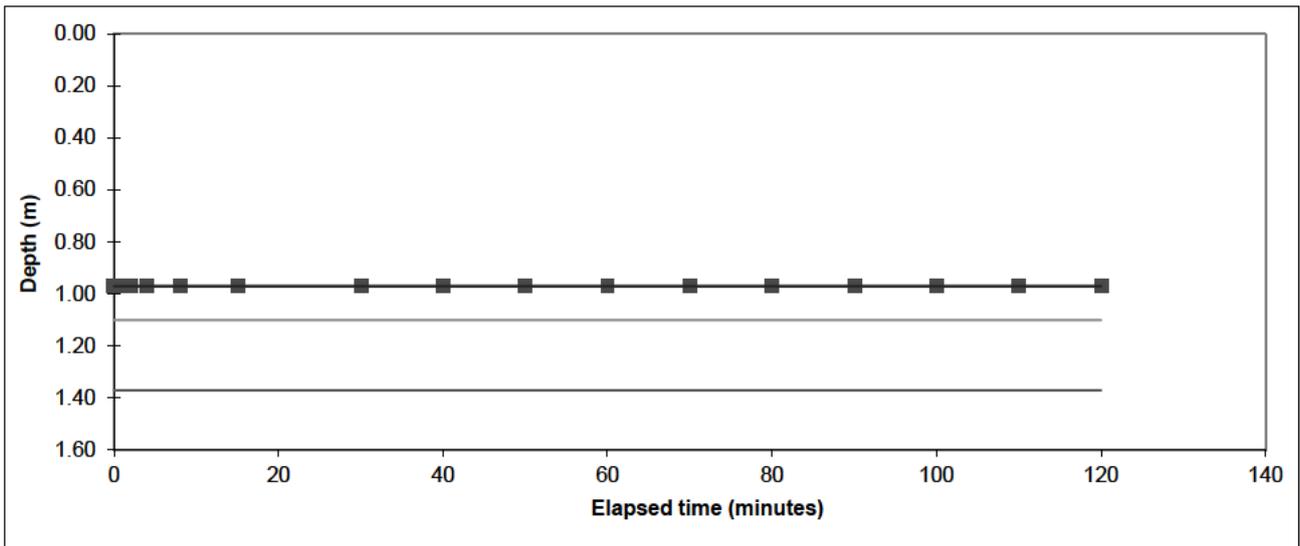
Soakaway Test Results

Rogers Geotechnical Services L

Soakaway Test

Trial Pit No:	TP01	Test No:	1	Date:	10/10/2022
Length (m):	1.800	Datum Height:			0.00 m agl
Width (m):	0.35	Granular infill:	None		
Depth (m):	1.50	Porosity of infill:	1	(assumed)	

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	0.970	110	0.970
1	0.970	120	0.970
2	0.970		
4	0.970		
8	0.970		
15	0.970		
30	0.970		
40	0.970		
50	0.970		
60	0.970		
70	0.970		
80	0.970		
90	0.970		
100	0.970		



Start water depth for analysis (mbgl):	0.97	Elapsed time (mins):	#N/A
75% effective depth (mbgl):	1.10		
50% effective depth (mbgl):	1.24	Elapsed time (mins):	#N/A
25% effective depth (mbgl):	1.37		
Base of soakage zone (mbgl):	1.50		
Volume outflow between 75% and 25% effective depth (m ³):			
Mean surface area of outflow (m ²):			1.75
(side area at 50% effective depth + base area)			
Time for outflow between 75% and 25% effective depth (mins):			

Soil infiltration rate (m/s):	Test incomplete as 25% effective depth not achieved. Unable to reliably determine soil infiltration rate.
--------------------------------------	--

Remarks	Results processed following BRE 365 (2007). Pit depth due to intended use of site - Shallow permeable asphalt.
----------------	---

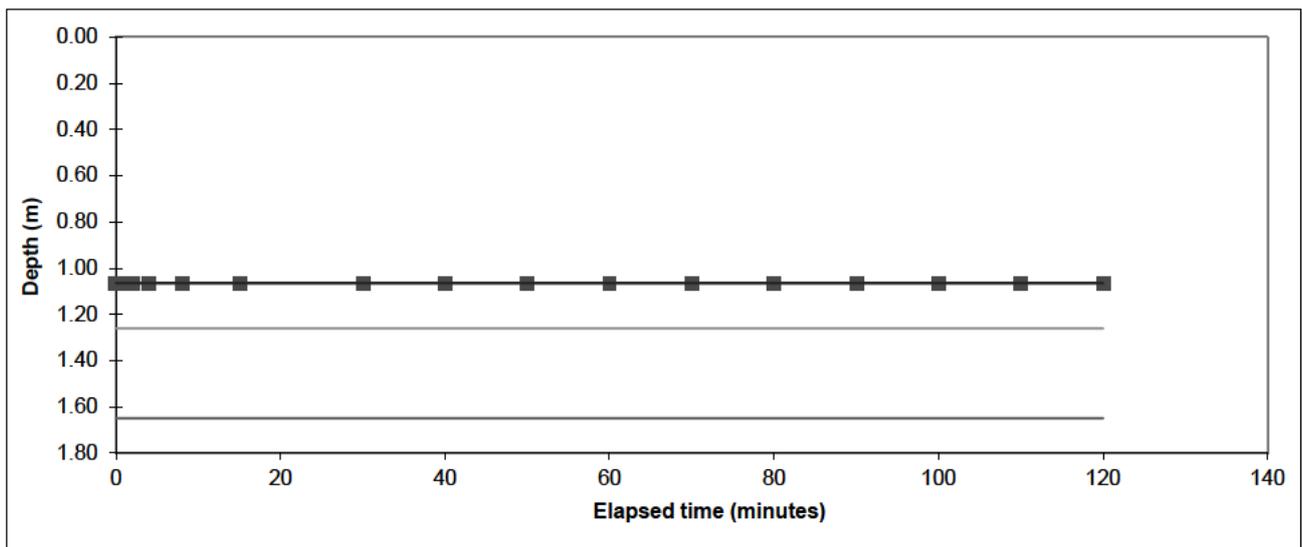
Client:	Studio91 Architecture	Job No:	C2764/22/E/4214
Site:	Land at Halifax Road, Liversedge		

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Soakaway Test

Trial Pit No:	TP02	Test No:	1	Date:	10/10/2022
Length (m):	2.100	Datum Height:			0.00 m agl
Width (m):	0.40	Granular infill:	None		
Depth (m):	1.85	Porosity of infill:	1	(assumed)	

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	1.065	110	1.065
1	1.065	120	1.065
2	1.065		
4	1.065		
8	1.065		
15	1.065		
30	1.065		
40	1.065		
50	1.065		
60	1.065		
70	1.065		
80	1.065		
90	1.065		
100	1.065		



Start water depth for analysis (mbgl):	1.07	Elapsed time (mins):	#N/A
75% effective depth (mbgl):	1.26	Elapsed time (mins):	#N/A
50% effective depth (mbgl):	1.46	Elapsed time (mins):	#N/A
25% effective depth (mbgl):	1.65	Elapsed time (mins):	#N/A
Base of soakage zone (mbgl):	1.85		
Volume outflow between 75% and 25% effective depth (m ³):			
Mean surface area of outflow (m ²):			2.79
(side area at 50% effective depth + base area)			
Time for outflow between 75% and 25% effective depth (mins):			

Soil infiltration rate (m/s):	Test incomplete as 25% effective depth not achieved. Unable to reliably determine soil infiltration rate.
--------------------------------------	--

Remarks	Results processed following BRE 365 (2007).
----------------	---

Client:	Studio91 Architecture	Job No:	C2764/22/E/4214
Site:	Land at Halifax Road, Liversedge		

Appendix 6

Laboratory Testing

Environmental
Geotechnical
Specialists



LABORATORY REPORT

< ENVIRONMENTAL >
< GEOTECHNICAL >

job number	C/2764/22/E/4214	date	09/01/2023
site address	Land at Halifax Road, Liversedge, West Yorkshire, WF15 8HE		
date scheduled	24/10/2022	date issued	09/01/2023
issued by	H J Letch		

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8948

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 Pt 12 : 2018 : 5.3 / 5.5	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		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		A	
ii. Large pycnometer	Pt 2 : 8.3			U
iii. Small pycnometer	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				
ii. Mass loss on ignition	Pt 3 : 4			U
3. COMPACTION RELATED TESTS				
3.1 Dry density/moisture relationship				
i. 2.5kg rammer – 1 litre mould	Pt 4 : 3		A	
- CBR mould	Pt 4 : 3		A	
ii. 4.5kg rammer – 1 litre mould	Pt 4 : 3		A	
- CBR mould	Pt 4 : 3		A	
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		A	
ii. Recompacted sample	Pt 5 : 7		A	
iii. Soaked, inc measurement of swell	Pt 5 : 7		A	
4. COMPRESSIBILITY OF SOIL				
ii. Swelling pressure test	Pt 5 : 3		A	
ii. Swelling pressure test	Pt 5 : 3			U
5. SHEAR STRENGTH OF SOIL				
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		A	
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

ENVIRONMENTAL & GEOTECHNICAL





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Disclaimer

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



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GEOTECHNICAL TESTING RESULTS



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 Offices 1&2,
 Bamcliffe Business Park,
 Near Bank, Shelley,
 Huddersfield,
 HD8 8LU

Classification of Index Properties

C2764/22/E/4214

Project Name: Land at Halifax Road, Liversedg

BS EN ISO: 17892: Parts 1, 12

Fig. 2
 Sheet. 1

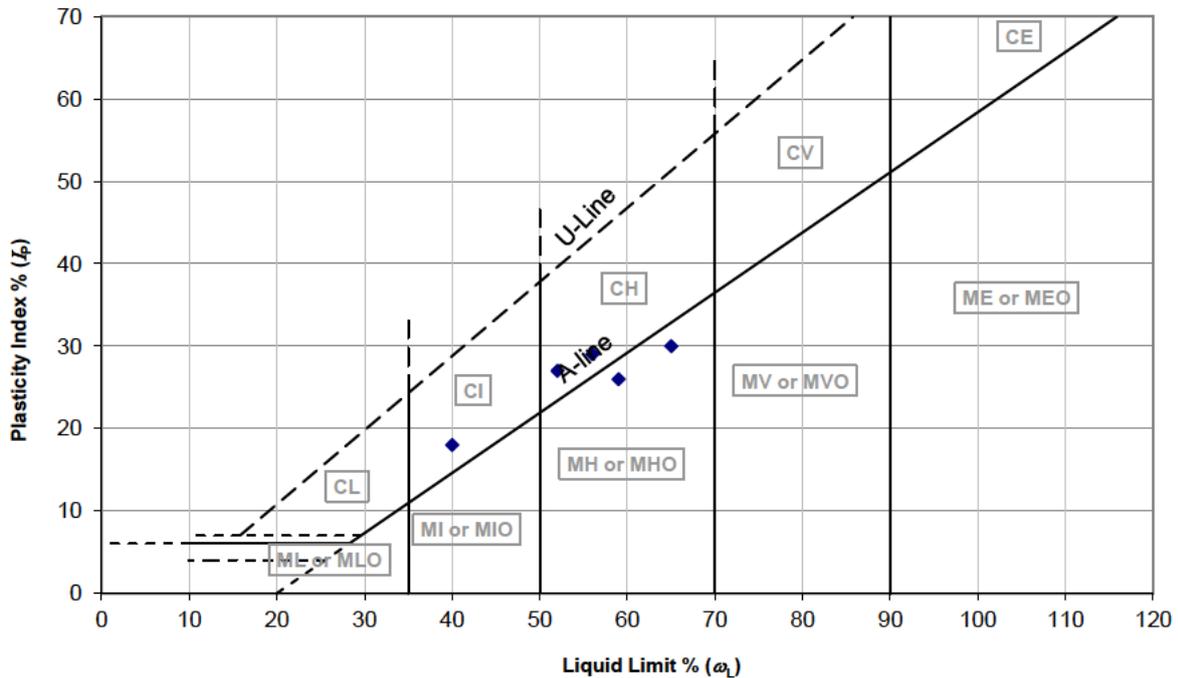
Location:

Input By: Harry

Client: Studio91 Architecture

Check By: Harry

Location	Depth (m)	Water Content (w) (%)	Liquid Limit (wL) (%)	Plastic Limit (wP) (%)	Plasticity Index (IP) (%)	Retained by 0.425mm (%)	Modified (w) (w') (%)	Modified (IP) (IP') (%)	Liquidity/ Consistency		Casagrande Class	N.H.B.C Class (%)
									(IL) (%)	(IC) (%)		
WS01	0.80	25.3	40	22	18	2	26	18	0.2	0.8	C I	LOW
WS01	1.50	23.1	52	25	27	4	24	26	-0.1	1.1	C H	MEDIUM
WS02	1.00	21.2	56	27	29	5	22	28	-0.2	1.2	C H	MEDIUM
WS03	1.20	38.3	59	33	26	49	75	13	0.2	0.8	M H	LOW
WS03	1.80	44.3	65	35	30	2	45	29	0.3	0.7	M H	MEDIUM





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ENVIRONMENTAL TESTING RESULTS



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Final Report

Report No.: 22-41969-1

Initial Date of Issue: 05-Jan-2023

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: C2764/22/E Liversedge

Quotation No.: Q21-25205 **Date Received:** 02-Nov-2022

Order No.: **Date Instructed:** 08-Nov-2022

No. of Samples: 3

Turnaround (Wkdays): 10 **Results Due:** 21-Nov-2022

Date Approved: 05-Jan-2023

Approved By:


Details: Stuart Henderson, Technical Manager

Results - Soil

Project: C2764/22/E Liversedge

Client: Rogers Geotechnical Services Ltd	Chemtest Job No.:				22-41969	22-41969	22-41969
Quotation No.: Q21-25205	Chemtest Sample ID.:				1537098	1537099	1537100
	Sample Location:				WS01	WS02	WS04
	Sample Type:				SOIL	SOIL	SOIL
	Top Depth (m):				0.25	0.50	0.50
	Date Sampled:				25-Oct-2022	25-Oct-2022	25-Oct-2022
	Asbestos Lab:				NEW-ASB	NEW-ASB	NEW-ASB
Determinand	Accred.	SOP	Units	LOD			
Cadmium	M	2455	mg/kg	0.10	0.55	0.22	1.0
Chromium (Hexavalent)	N	2490	mg/kg	0.50	< 0.50	< 0.50	< 0.50
Copper	M	2455	mg/kg	0.50	15	15	11
Mercury	M	2455	mg/kg	0.05	< 0.05	< 0.05	0.10
Nickel	M	2455	mg/kg	0.50	16	7.5	8.3
Lead	M	2455	mg/kg	0.50	20	26	17
Zinc	M	2455	mg/kg	0.50	48	38	130
Vanadium	U	2455	mg/kg	0.5	63	14	8.1
Arsenic	M	2455	mg/kg	0.5	3.1	3.8	4.1
Selenium	M	2455	mg/kg	0.25	1.0	2.0	0.29
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	0.41	0.50	< 0.10
Acenaphthylene	M	2700	mg/kg	0.10	0.65	3.3	< 0.10
Acenaphthene	M	2700	mg/kg	0.10	0.37	3.0	< 0.10
Fluorene	M	2700	mg/kg	0.10	0.26	2.5	< 0.10
Phenanthrene	M	2700	mg/kg	0.10	3.3	40	< 0.10
Anthracene	M	2700	mg/kg	0.10	1.6	20	< 0.10
Fluoranthene	M	2700	mg/kg	0.10	10	250	0.57
Pyrene	M	2700	mg/kg	0.10	12	270	0.86
Benzo[a]anthracene	M	2700	mg/kg	0.10	8.0	90	0.42
Chrysene	M	2700	mg/kg	0.10	9.6	99	0.73
Benzo[b]fluoranthene	M	2700	mg/kg	0.10	13	160	< 0.10
Benzo[k]fluoranthene	M	2700	mg/kg	0.10	5.0	46	< 0.10
Benzo[a]pyrene	M	2700	mg/kg	0.10	12	95	< 0.10
Indeno(1,2,3-c,d)Pyrene	M	2700	mg/kg	0.10	11	59	< 0.10
Dibenz(a,h)Anthracene	M	2700	mg/kg	0.10	4.4	16	< 0.10
Benzo[g,h,i]perylene	M	2700	mg/kg	0.10	14	50	< 0.10
Total Of 16 PAH's	M	2700	mg/kg	2.0	110	1200	2.6
pH	M	2010		4.0	9.5	9.2	9.4
Sulphate (2:1 Water Soluble) as SO4	M	2120	g/l	0.010	< 0.010	0.011	< 0.010
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	6.4	11	10
Soil Colour	N	2040		N/A	Brown	Brown	Brown
Other Material	N	2040		N/A	Stones and Roots	Stones	Stones

Results - Soil

Project: C2764/22/E Liversedge

Client: Rogers Geotechnical Services Ltd	Chemtest Job No.:				22-41969	22-41969	22-41969
Quotation No.: Q21-25205	Chemtest Sample ID.:				1537098	1537099	1537100
	Sample Location:				WS01	WS02	WS04
	Sample Type:				SOIL	SOIL	SOIL
	Top Depth (m):				0.25	0.50	0.50
	Date Sampled:				25-Oct-2022	25-Oct-2022	25-Oct-2022
	Asbestos Lab:				NEW-ASB	NEW-ASB	NEW-ASB
Determinand	Accred.	SOP	Units	LOD			
Soil Texture	N	2040		N/A	Sand	Sand	Sand
Sulphate (Total)	U	2430	%	0.010	0.17	0.15	0.047
Aliphatic VPH >C5-C6	N	2780	mg/kg	0.05	0.18	< 0.05	< 0.05
Aliphatic VPH >C6-C7	N	2780	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Aliphatic VPH >C7-C8	N	2780	mg/kg	0.05	< 0.05	0.12	0.12
Aliphatic VPH >C8-C10	N	2780	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Total Aliphatic VPH >C5-C10	N	2780	mg/kg	0.25	< 0.25	< 0.25	< 0.25
Aliphatic EPH >C10-C12	N	2690	mg/kg	2.00	< 2.0	< 2.0	< 2.0
Aliphatic EPH >C12-C16	N	2690	mg/kg	1.00	1.3	< 1.0	1.3
Aliphatic EPH >C16-C21	N	2690	mg/kg	2.00	< 2.0	2.6	< 2.0
Aliphatic EPH >C21-C35	N	2690	mg/kg	3.00	< 3.0	4.4	< 3.0
Aliphatic EPH >C35-C40	N	2690	mg/kg	1.00	< 1.0	< 1.0	< 1.0
Total Aliphatic EPH >C10-C35	N	2690	mg/kg	5.00	< 5.0	8.4	5.8
Aromatic VPH >C5-C7	N	2780	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Aromatic VPH >C7-C8	N	2780	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Aromatic VPH >C8-C10	N	2780	mg/kg	0.05	< 0.05	0.39	0.38
Total Aromatic VPH >C5-C10	N	2780	mg/kg	0.25	< 0.25	< 0.25	< 0.25
Aromatic EPH >C10-C12	N	2690	mg/kg	1.00	< 1.0	< 1.0	< 1.0
Aromatic EPH >C12-C16	N	2690	mg/kg	1.00	2.6	6.0	1.0
Aromatic EPH >C16-C21	N	2690	mg/kg	2.00	46	170	2.8
Aromatic EPH >C21-C35	N	2690	mg/kg	2.00	140	260	2.7
Aromatic EPH >C35-C40	N	2690	mg/kg	1.00	40	2.6	3.6
Total Aromatic EPH >C10-C35	N	2690	mg/kg	5.00	190	430	6.6
Total VPH >C5-C10	N	2780	mg/kg	0.50	< 0.50	< 0.50	< 0.50
Total EPH >C10-C35	N	2690	mg/kg	10.00	190	440	12
Organic Matter	M	2625	%	0.40	8.5	16	4.3
Benzene	M	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0
Toluene	M	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0
Ethy benzene	M	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0
m & p-Xylene	M	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0
o-Xylene	M	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0
Methyl Tert-Butyl Ether	M	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0

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.
2455	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.
2690	EPH A/A Split	Aliphatics: >C10–C12, >C12–C16, >C16–C21, >C21– C35, >C35– C40 Aromatics: >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C40	Acetone/Heptane 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)
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2780	VPH A/A Split	Aliphatics: >C5–C6, >C6–C7,>C7–C8,>C8–C10 Aromatics: >C5–C7,>C7-C8,>C8–C10	Water extraction / Headspace GCxGC FID detection
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



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End of Report



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☎ 01484 604354 Company No. 5130864

Appendix 7

Fill Screening Values

Rogers Geotechnical Services Ltd.

Atkins ATRISK Soil Screening Values (SSVs) - Residential With Plant Uptake Landuse

Tox Data Report No.	Compound	Residential with Homegrown Produce Landuse (mg/kg)				Reference
		SOM: 1%		SOM: 6%		
<i>Metals</i>						
3	Cadmium	22.1		22.1		C
4	Chromium VI	3.62	20.5	3.63	20.5	B/C
	Copper	4730		4790		A+
7	Mercury	8.81		15.80		A/D
8	Nickel	136		136		A+
	Lead	200		200		C
	Zinc	20000		20300		A+
	Vanadium	136		138		A+
<i>Semi and Non Metals</i>						
1	Arsenic	37		37		C
10	Selenium	375		375		A
	Free Cyanide	34		34		A
9	Phenols (total)	267		1200		A
<i>Poly Aromatic Hydrocarbons</i>						
20	Napthalene	0.829	No free product	12.2	No free product	A+
	Acenaphthene	157	608	2760		A+
	Fluorene	735		2610		A+
	Anthracene	10200		26200		A+
	Fluoranthene	983		2980		A+
	Pyrene	668		2120		A+
	Benzo(a)anthracene	1.71	4.52			A
2	Chrysene	0.44	585			A
2	Benzo(b)fluoranthene	1.22	7.72			A
2	Benzo(k)fluoranthene	0.686	84.4			A
2	Benzo(a)pyrene	1.51	4.95	2.05	4.95	B/C
2	Dibenzo(a,h)anthracene	0.00393	0.838			A*
2	Indeno(1,2,3-cd)pyrene	0.0614	7.31			A
2	Benzo(g,h,i)perylene	0.0187	96.2			A
<i>Petroleum Hydrocarbons</i>						
	Aliphatic C5-C6	42.7		369		A+
	Aliphatic C6-C8	99.3		768	1240	A+
	Aliphatic C8-C10	13.9		204		A+
	Aliphatic C10-C12	49.9	81.7	297	1180	A+
	Aliphatic C12-C16	20.9	385	125	4130	A+
	Aliphatic C16-C21	210000		210100		A+
	Aliphatic C21-C35	210000		210100		A+
	Aromatic C5-C7 (Benzene)	0.137		0.871		A+
	Aromatic C7-C8 (Toluene)	113		780		A+
	Aromatic C8-C10	20.5		232		A+
	Aromatic C10-C12	70		468		A+
	Aromatic C12-C16	155	165	830		A+
	Aromatic C16-C21	319		1040		A+
	Aromatic C21-C35	1120		1710		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 = Category 4 Screening Levels (C4SLs).						
D = SSV provided is for Methyl Mercury.						