



EARTH ENVIRONMENTAL
& GEOTECHNICAL

GeoEnvironmental Investigation

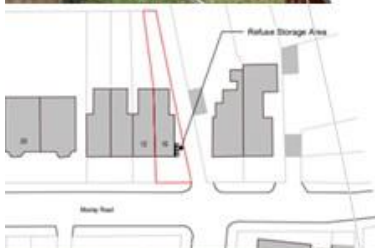
Moxley Road

Crumpsall

September 2021

On behalf of

Welcome Estates



Earth Environmental & Geotechnical Ltd
Houldsworth Mill Business & Arts Centre
Houldsworth Street
Stockport
SK5 6DA

Tel : 0161 975 6088

Email info@earthenvironmental.co.uk
www.earthenvironmental.co.uk

SITE INVESTIGATION

MOXLEY ROAD

CRUMPSALL

Report Ref: A4255/21

SEPTEMBER 2021

Prepared on Behalf of:

WELCOME ESTATES

By:

Earth Environmental & Geotechnical Ltd
Houldsworth Mill Business & Arts Centre
Houldsworth Street
Stockport
SK5 6DA

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Prepared by: Earth Environmental & Geotechnical Ltd
Houldsworth Mill Business & Arts Centre
Houldsworth Street
Stockport
SK5 6DA

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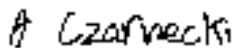


Amy Ellams
GeoEnvironmental Consultant

Reviewed by:



Dr. Shauna McLoughlin
Senior GeoEnvironmental Consultant



Approved by:

Adam Czarnecki
Managing Director

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1.0 EXECUTIVE SUMMARY

Appointment	A Site Investigation has been commissioned by Welcome Estates (the 'Client') to examine ground conditions for a proposed residential development at a site located at 10 Moxley Road, Crumpsall.
The Investigation	The investigation comprised three window sample boreholes and two foundation pits with associated sampling and in situ testing, laboratory geotechnical and contamination testing.
The Site	The site is in Crumpsall, Greater Manchester, Northwest England approximately 0.84km of Crumpsall Town Centre. The approximate National Grid Reference for the centre of the site is SD 83539 02373 (X: 383539, Y: 402373). The site is underlain by Glaciofluvial Deposits, and the bedrock geology comprises the Manchester Marls Formation.
Site History	Historically, the site was occupied by an end of terrace dwelling with a shed/garage in the rear garden in 1890. The shed/garage was demolished by 1922 and the building demolished by 1963-1974. The site is currently a derelict parcel of land with waste bins from the adjoining property and fly tipped materials present.
Ground Conditions Encountered	The exploratory holes encountered Made Ground to a maximum depth of 2.00m bgl (WS02). Underlying the Made Ground were superficial deposits of variable clay, silt, and sand to a maximum depth of 6.00m bgl. Groundwater was encountered in WS01 and WS02 during the fieldwork.
Geotechnical Assessment	Shallow strip/pad foundations placed in the superficial deposits at a minimum depth of approximately 2.00m bgl are considered appropriate for the proposed development. Pavement Design – preliminary design value = 1% in Made Ground, up to 20% in natural strata. Design Sulphate Class = DS-1 ACEC Site Classification = AC-1s
Contamination Assessment	Risk from contamination to groundworkers during development – Low Risk from contamination to future site users – Low. Soil Waste Assessment: 2 samples tested all classified as Non-Hazardous.
<i>This sheet is intended to provide a summary only of the report. It does not provide a definitive engineering analysis for the purposes of costing or construction and is subject to the limitation of the agreed brief.</i>	

2.0 INTRODUCTION

2.1 Background

A Site Investigation has been commissioned by Welcome Estates (the Client) to examine ground conditions for a proposed new residential development at a site off Moxley Road, Crumpsall.

2.2 Previous Investigations

2.2.1 Earth Environmental & Geotechnical Ltd, Phase I GeoEnvironmental Desk Study (A4255/21), dated July 2021

Historically the site was occupied by an end of terrace dwelling with a shed/garage in the rear garden in 1890. The shed/garage was demolished by 1922 and the building demolished by 1963-1974. The site is currently a derelict parcel of land with waste bins from the adjoining property and fly tipped materials present which may be sources of contamination.

Potential sources of contamination were identified as Made Ground, associated ground gas and asbestos containing materials from former structures and fly-tipped material. Potential off-site sources of contamination were identified as nurseries located 2m to the north of the site.

The risk from soil contamination to residential end users was **MODERATE** to **LOW**. The risk to controlled waters was concluded to be **VERY LOW**. The risk from ground gas to end users was **LOW**. The risk of groundwater flooding was **MODERATE**.

An intrusive investigation was recommended to establish geotechnical parameters for the design of foundations, floor slabs and pavement construction. As part of the geotechnical investigation, it was recommended that samples are recovered for contamination testing and to confirm whether there are any potential risks.

2.2.2 Planning Application to Manchester City Council, 081846/FO/2007/N1, dated February 2007.

A planning application was submitted to Manchester City Council (Reference: 081846/FO/2007/N1) for the proposed erection of a 3-storey end terrace house. The application was withdrawn in March 2007.

2.2.3 Planning Application to Manchester City Council, 130239/FO/2021, dated May 2021.

A planning application was submitted to Manchester City Council (Reference: 130239/FO/2021) for the proposed erection of a 3-storey end terrace dwelling house. The application was approved in July 2021.

2.3 Terms of Reference

Earth Environmental and Geotechnical Ltd (EEG) have been commissioned by the Client, to undertake a Site Investigation of the site in accordance with proposal A4255/21 dated 4th August 2021. The objectives of this investigation are as follows:

- *Provide factual information on the work undertaken including sampling location plan, borehole logs, geotechnical and chemical testing.*

- *Tier 1 (semi-quantitative) risk assessment will be undertaken. This will compare the concentrations of soil contaminants identified against current and appropriate published guidelines, in relation to identified receptors, e.g., existing/ future end users and site neighbours.*
- *Classification of soil for offsite disposal.*
- *Assessment of ground conditions for foundation and soakaway design.*

2.4 Report Scope

This report presents full factual records of the site work carried out, the ground conditions encountered in the exploratory holes, the in situ and laboratory test results. All information collected has been used to provide an interpretation of the ground conditions, with recommendations on geotechnical design and potential ground contamination risks for the proposed development.

2.5 Limitations of the Study

The report is written in the context of an agreed scope of work and budget and should not be used in a different context. New information, improved practices or changes in legislation may require a reinterpretation of the report in whole or in part. EEG reserve the right to amend either conclusions or recommendations considering any further information that may become available. The report is provided for the sole use by the client and is confidential to them.

Recommendations within this report are also based on exploratory records and examination of samples and, where applicable, laboratory tests. No liability can be accepted for conditions not revealed by the boreholes particularly at intervening locations. Whilst every effort is made to ensure accuracy of data supplied, all opinions expressed as to the spatial distribution of strata between sampling locations is for guidance only and no responsibility is accepted as to its accuracy.

3.0 SITE LOCATION & DESCRIPTION

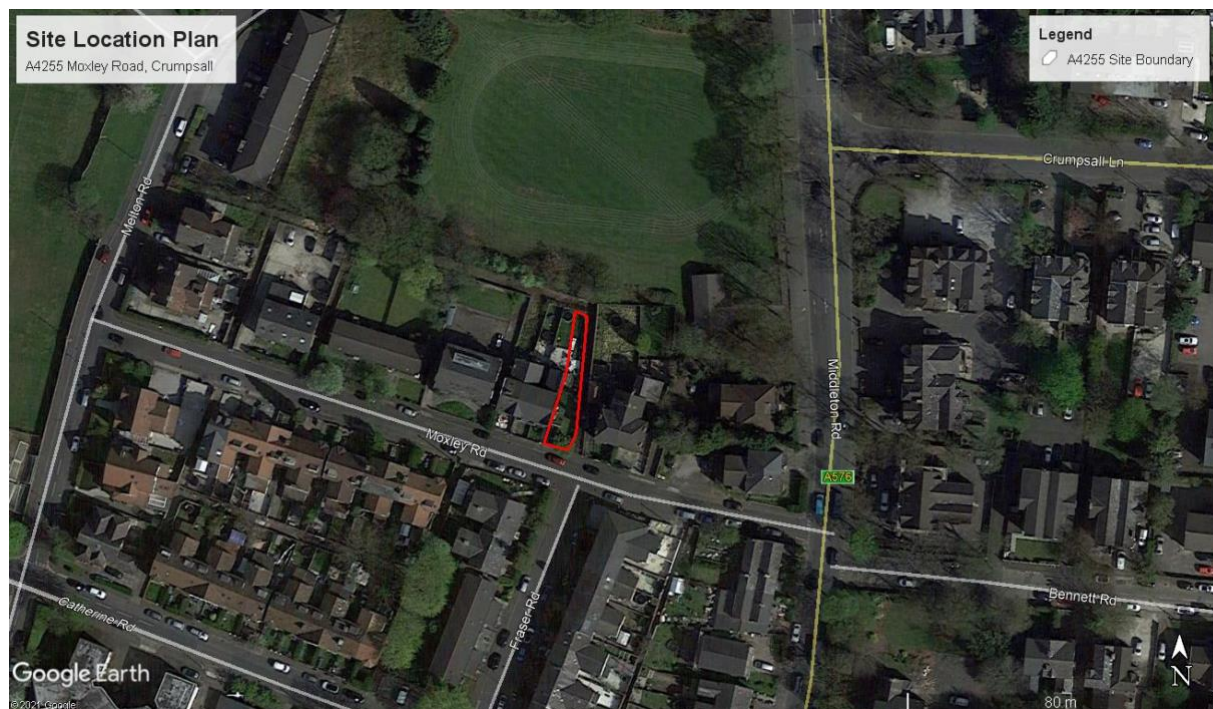
The site is in Crumpsall, Greater Manchester, Northwest England approximately 4km north of Manchester City Centre. The approximate National Grid Reference for the centre of the site is SD 83539 02373 (X: 383539, Y: 402373), with the closest postcode being M8 4HJ.

The site is a near rectangular shaped parcel of land currently accessible via Moxley Road. The site is currently accessed via a gate way to the south of the site. The area of the site is 0.02hectares with a generally level topography across the site.

The surrounding area predominantly comprises of residential dwellings with a large green space located to the north of the site.

The site location is shown in the aerial photograph presented as Figure 1, below.

Figure 1: Aerial Photograph Showing Site Location



A site photographs is presented in Figure 2 overleaf.

Figure 2: General Site Photographs

Photograph taken across the site viewing north



Photograph taken showing soils recovered from WS03



3.1 Proposed Development

It is understood that the client intends to construct a residential development on the site comprising a three storey, end terrace dwelling house. The development will consist of 5no. bedrooms and front and rear gardens.

The proposed development layout details are shown in Figure 3 below.

Figure 3: Proposed Development Plan



4.0 SITE INVESTIGATION

4.1 Exploratory Fieldwork

The fieldwork was carried out by EEG on 20th August 2021 and comprised:

- Three window sample boreholes (designated WS01 to WS03 inclusive) were each sunk to a depth of 6.00m below existing ground level. Window sampler boring is carried out with a small, track-mounted rig, which uses a chain-driven trip hammer to drive sampling tubes or penetrometers into the ground. These tools are coupled to the anvil of the hammer by solid drill rods. Sampling tubes comprise “windowless samplers”, which are plain sampler tubes in which a continuous disturbed sample is recovered within a semi-rigid plastic liner. In order to reduce friction within the borehole, sampling tubes of progressively smaller diameter are used as the borehole depth increases. Sampler diameters generally range from between approximately 90mm to 50mm. Standard Penetration Tests (SPTs) were undertaken in the boreholes in accordance with BS EN ISO 22476-3. Groundwater observations were noted where possible. These observations relate to the time of the investigation only, and do not necessarily reflect seasonal fluctuations. Exploratory hole logs are included in Appendix 1.
- Upon completion, all three of the boreholes (WS01, WS02 & WS03) were fitted with groundwater monitoring installations.
- Falling head tests were conducted in WS01, WS02 and WS03 on a return visit to the site, to determine soil permeability. The results of the tests are discussed in Section 7.5 and presented in Appendix 2.
- Two trial pits (designated TP01 and TP02) were excavated to a maximum depth of 1.20m bgl to inspect the existing foundations of the adjacent terrace dwelling. Trial pits were backfilled immediately on completion. Trial pit logs are presented in Appendix 1.

Exploratory hole locations were selected on-site by an EEG engineer based on the proposed development layout, targeting areas of potential contamination, and avoiding known services.

Each exploratory location was scanned using a Cable Avoidance Tool (CAT) to locate unrecorded underground services, and the exploratory locations were repositioned if necessary.

On completion, samples recovered from the site were taken to specialist laboratories for chemical and geotechnical testing.

Soil samples of approximately 500g were recovered in amber jars and amber vials for volatile analysis as well as plastic tubs for general analysis. All the samples were labelled and stored in cool boxes prior to being collected by courier at the end of the day for delivery to the DETS laboratory.

If collection was not possible the same day, then samples were stored in the sample storage fridge at the EEG offices below 4°C.

Samples were tracked using appropriate Chain of Custody forms provided by DETS.

It should be noted that hexavalent chromium soil is analysed using the USEPA recommended method of alkaline leach. This method limits chromium (VI) reduction to chromium (III).

All site investigation work was supervised full time by a representative of EEG. The logging of soils and rocks has been carried out in accordance with BS5930^(2015+A1:2020) except where superseded by the soil and rock description methodology in BS EN14688-1⁽²⁰⁰²⁾, BS EN 14688-2⁽²⁰⁰⁴⁾ and BS EN 14689-1⁽²⁰⁰³⁾.

All sampling locations were surveyed by use of a hand-held Trimble GeoXH GPS instrument that is capable of surveying to an accuracy of less than 10mm depending on satellite coverage, proximity to trees and building structures.

The descriptive terminologies such as firm, etc formerly used within older versions of BS5930 to describe strength now solely relate to consistency. Shear strength is now defined related to results obtained in the field (using a hand vane for example) or in the laboratory (from triaxial tests), as detailed in Table 1 below.

Table 1: Shear Strength Definitions

Term based on measurement	Undrained Strength (c_u) definition in kN/m ² (from BS EN ISO 14688-2: 2004, 5.3, Table 5)
Extremely Low Strength	<10
Very Low Strength	10 to 20
Low Strength	20 to 40
Medium Strength	40 to 75
High Strength	75 to 150
Very High Strength	130 to 300
Extremely High Strength	300 to 600

An Exploratory Hole Location Plan is presented as Figure 4, below.

Figure 4: Exploratory Hole Location Plan



A summary of exploratory holes undertaken during the investigation are presented in Table 2 below.

Table 2: Summary of Exploratory Holes Undertaken

Hole	Type*	Depth (m)	Date Started	Date Finished	Easting (m)	Northing (m)	Backfill Details**
WS01	WS	6.00	20/08/2021	20/08/2021	383539	402368	SP
WS02	WS	6.00	20/08/2021	20/08/2021	383541	402373	SP
WS03	WS	6.00	20/08/2021	20/08/2021	383542	402378	SP
TP01	TP	1.20	20/08/2021	20/08/2021	383537	402371	A
TP02	TP	1.20	20/08/2021	20/08/2021	383536	402367	A
*WS = Window Sample Borehole, TP = Trial Pit							
**SP = Standpipe, A = Arisings							

4.2 Laboratory Testing

4.2.1 Geotechnical Testing

A programme of laboratory testing was carried out on samples taken from the various strata to assist in classification and determine the engineering properties of the materials underlying the site. The tests were scheduled by EEG and carried out by Murray Rix. The test procedures used were generally in accordance with the methods described in BS1377:1990. Details of the specific tests used in each case are given in Table 3, overleaf.

Table 3: Summary of Laboratory Geotechnical Tests Undertaken

TEST	STANDARD	No.
Moisture Content	BS1377:1990 Part 2, Clause 3.2	2
Liquid Limit, Plastic Limit, Plasticity Index	BS1377:1990 Part 2, Clause 4/5	2
Sulphate content of 2:1 soil: water extract	BS1377:1990 Part 3, Clause 5	2
pH value	BS1377:1990 Part 3, Clause 9	2

The results of the laboratory geotechnical tests are discussed in Section 6 and included in Appendix 3.

4.2.2 Environmental Testing

The environmental chemistry of the ground was investigated by specialist chemical analysis of selected samples, scheduled by EEG, and carried out by DETS, a UKAS and MCERTS accredited laboratory.

Chemical analyses were carried out on two soil samples and were submitted for the following suite of determinants:

Asbestos Screen, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Vanadium, Zinc, Cyanide, Phenol, Sulphate (SO₄), Sulphide, pH, Soil Organic Matter, Extractable Petroleum Hydrocarbons (EPH), Speciated Petroleum Hydrocarbon (TPH) and Speciated Polyaromatic Hydrocarbons (PAH).

The results of the laboratory contamination tests are discussed in Section 8 and included in Appendix 4.

5.0 GROUND CONDITIONS ENCOUNTERED

5.1 Soil Profile Encountered

BGS digital mapping shows the site is underlain by superficial deposits of Glaciofluvial Sheet Deposits, comprising Devensian sand and gravel. The solid geology beneath the site is the Manchester Marls Formation, comprising mudstone. The sequence of strata encountered beneath the site was as follows:

- **Made Ground** – Variable Made Ground was encountered in all the exploratory holes, comprising:
 - Clayey gravelly SAND with gravel of redbrick, sandstone, mudstone, slate, glass, and concrete
 - Gravelly cobbly SAND with gravel of redbrick and cobbles of whole and broken redbrick
 - Clayey gravelly cobbly SAND with gravel of redbrick, sandstone, mudstone, concrete and cloth and cobbles of redbrick
 - Sandy gravelly CLAY with gravel of redbrick, sandstone, mudstone, and concrete
 - Gravelly SAND with gravel of redbrick and cobbles of whole and broken redbrick.

- **Superficial Deposits** –

Sand was encountered in exploratory boreholes WS01, WS02 and WS03 comprising:

- Clayey gravelly SAND with gravel of mudstone and carbonaceous fragments
- SAND
- Gravelly SAND with gravel of carbonaceous fragments and mudstone

Clay was encountered in exploratory boreholes WS01 and WS03 comprising:

- Silty sandy gravelly CLAY with gravel of sandstone and carbonaceous fragments

Silt was encountered in exploratory boreholes WS02 comprising:

- Clayey sandy gravelly SILT with gravel of mudstone.

The depths of the various materials encountered in the exploratory holes are summarised in Table 4 below.

Table 4: Summary of Ground Conditions Encountered

Hole	Depth to Stratum (m)					Ground-water (m bgl)
	MADE GROUND		SUPERFICIAL DEPOSITS			
	Granular	Cohesive	CLAY	SILT	SAND	
WS01	GL – 1.20	1.20 – 1.50	1.95 – 3.00	-	1.50 – 1.95 3.00 – 6.00+	2.80
WS02	GL – 2.00	-	-	2.00 – 3.60	3.60 – 6.00	2.00
WS03	GL – 1.30	-	1.30 – 1.50	-	1.50 – 6.00	-
TP01	GL – 1.20	-	-	-	-	-
TP02	GL – 1.20	-	-	-	-	-
Depths in red indicate termination in the made ground.						

5.2 Observable Indications of Contamination

Red brick, concrete and glass were observed in the Made Ground material, however these materials are generally considered inert.

No other visual or olfactory contamination was encountered during the field work.

5.3 Obstructions

No Man-Made obstructions were encountered in any of the exploratory hole locations.

5.4 Groundwater

Groundwater was encountered in boreholes WS01 and WS02 during the fieldwork at a depth of 2.80m bgl and 2.00m bgl.

The standing water levels recorded in the standpipes prior to falling head tests were 4.27m bgl in WS01, 2.82m bgl in WS02 and 4.24m bgl in WS03.

5.5 Existing Foundations

Two trial pits (TP01 and TP02) were advanced to identify/inspect the existing foundations, including the external walls of the terraced dwelling on the site boundary.

No existing foundations were identified within foundation pits excavated to a depth of 1.20m bgl.

Photographs of the foundations and schematic diagrams are included in Appendix 1.

6.0 ENGINEERING PROPERTIES OF SOILS ENCOUNTERED

6.1 General

The following sections discuss the engineering properties of the strata encountered, based on results of in situ testing and laboratory testing obtained during this investigation.

The results of laboratory geotechnical testing are summarised in the following table.

Table 5: Summary of Laboratory Geotechnical Test Results

Location	Depth (m)	Strata		CLASSIFICATION										STRENGTH	CHEMICAL	
			Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	PSD Cobbles (%)	PSD Gravel (%)	PSD Sand (%)	PSD Silt (%)	PSD Clay (%)	Bulk Density Mg/m³	Dry Density (Mg/m³)	Shear Strength (kN/m²)	pH Value	Water Soluble Sulphate SO ₄ (mg/l)
WS01	2.3	Clay	17	28	10	18	-	-	-	-	-	-	-	-	7.0	330
WS02	2.8	Silt	20	N/A	NP	N/A	-	-	-	-	-	-	-	-	-	-
WS03	1.5	Sand	-	-	-	-	-	-	-	-	-	-	-	-	7.0	120
NP=non-Plastic																

6.2 Made Ground

Made Ground was encountered in all exploratory hole locations between ground level and 2.00m below ground level (WS02) and varied from exploratory hole location.

SPT tests carried out in the deeper Made Ground resulted in **SPT N values** of 5 and 7, as shown on the SPT v Depth Plot, in Figure 5 (overleaf).

Made Ground is not typically considered to be a suitable founding material, and as such, no further geotechnical testing was carried out on the material.

6.3 Superficial Deposits

As discussed in Section 5, soils interpreted to represent the Glaciofluvial Sheet Deposits were encountered as SAND, clayey gravelly SAND, and gravelly SAND. However, a silty sandy gravelly CLAY and a clayey sandy gravelly SILT were also encountered in some the exploratory hole locations.

6.3.1 Clay

A silty sandy gravelly clay was encountered in exploratory hole locations WS01 and WS03 between 1.30 and 3.50m below ground level.

Laboratory testing has given a value of **water-soluble sulphate** of 330mg/l, together with a **pH Value** of 7.0.

SPT tests carried out in the clay resulted in **SPT N values** of between 7 and 13, as shown on the SPT v Depth Plot in Figure 5 (overleaf). The results suggest the clay is soft to firm.

In-situ **hand penetrometer** (HP) tests taken in the clay have given results of shear strength in the range 48kN/m² to 60kN/m², suggesting the clay is medium strength.

Figure 6, overleaf, shows the **shear strength** of the clay soils based on in-situ hand penetrometer tests alongside equivalent shear strength from SPT N values based on correlations by Stroud and Butler ⁽¹⁹⁷⁵⁾.

Recommended N values and derived design values for the clay soils are summarised in Table 6, below.

Table 6: Summary of Design Parameters (Clay)

Depth	SPT N Value Range	Average N Value	Design N Value*	Equivalent Shear Strength** (kN/m ²)	Coefficient of Volume Compressibility** (mv)
2.0	7	7	7	32 (low strength)	0.25
3.0	13	13	13	59 (medium strength)	0.13
*Based on lower quartile N value and correlations by Peck Hanson and Thornburn ⁽¹⁹⁷⁴⁾					
**Based on correlation by Stroud & Butler ⁽¹⁹⁷⁵⁾					

It is recommended that for assessing ultimate bearing capacities, where the lower values are critical, the lower quartile value of N values is used. Based on the N Values in the above table, the equivalent shear strength values were in the range of 32 - 59kN/m², which equate to clays of low strength to medium strength, based on Table 1.

Figure 5: SPT v Depth Plot

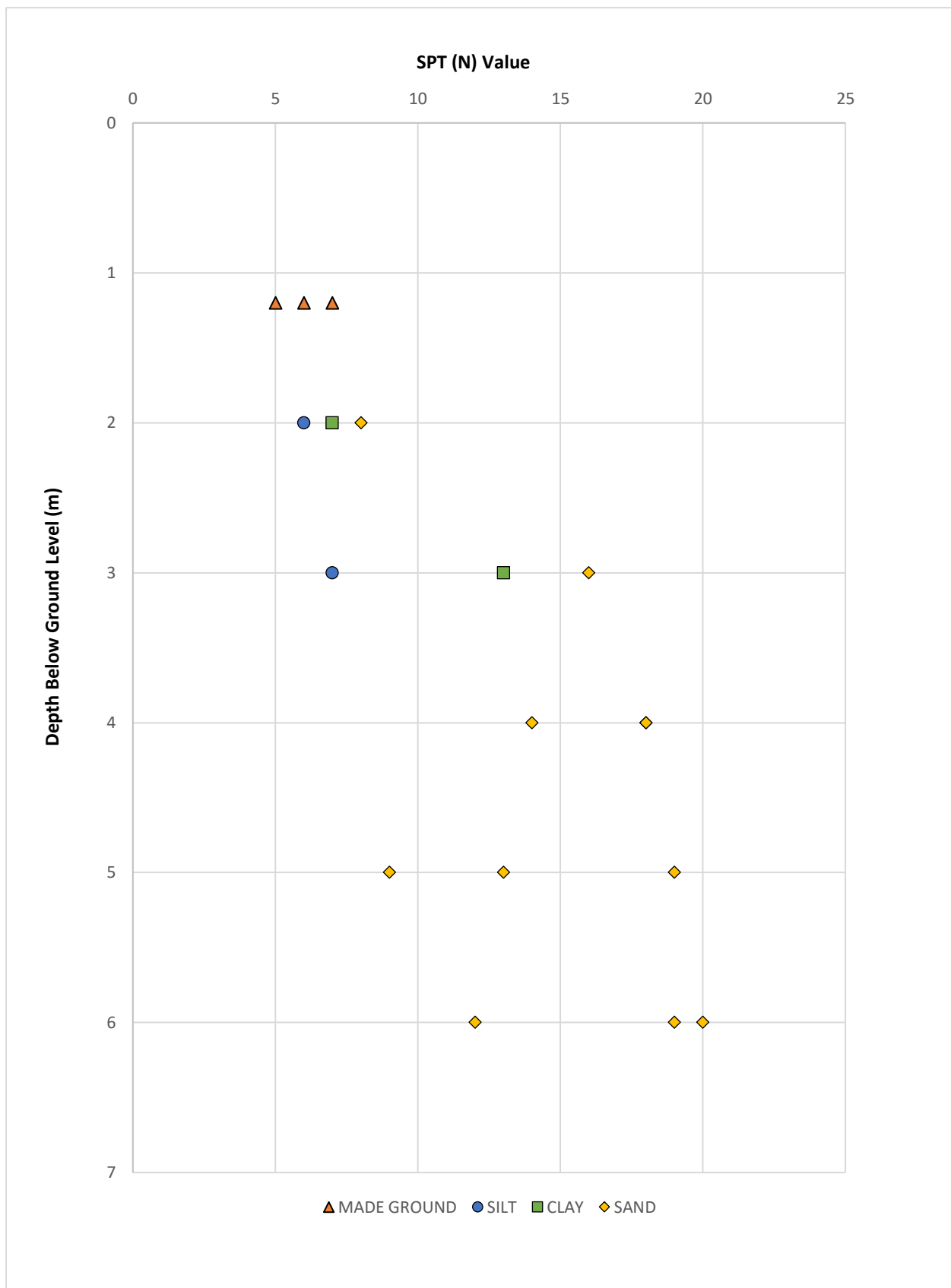
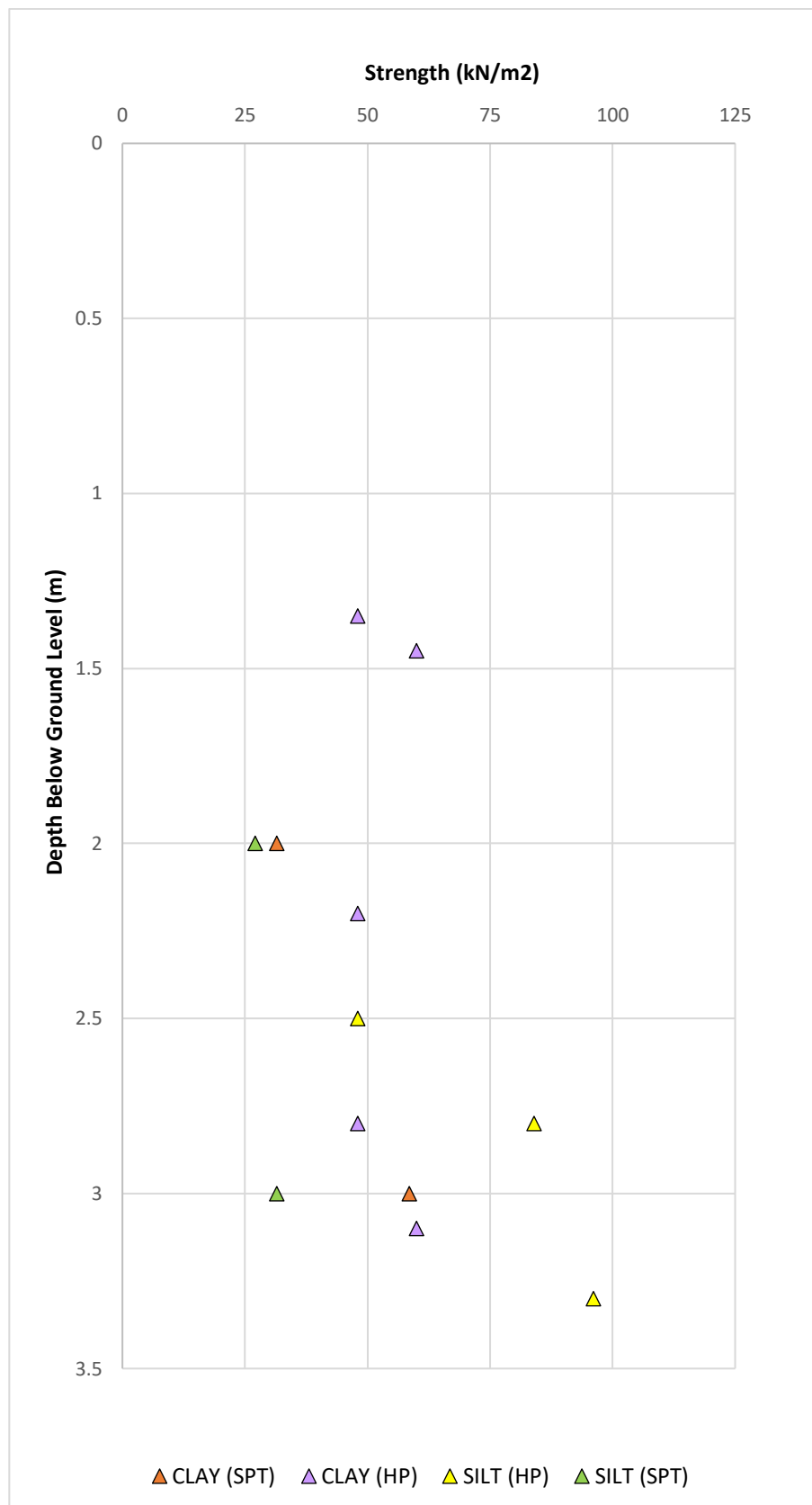
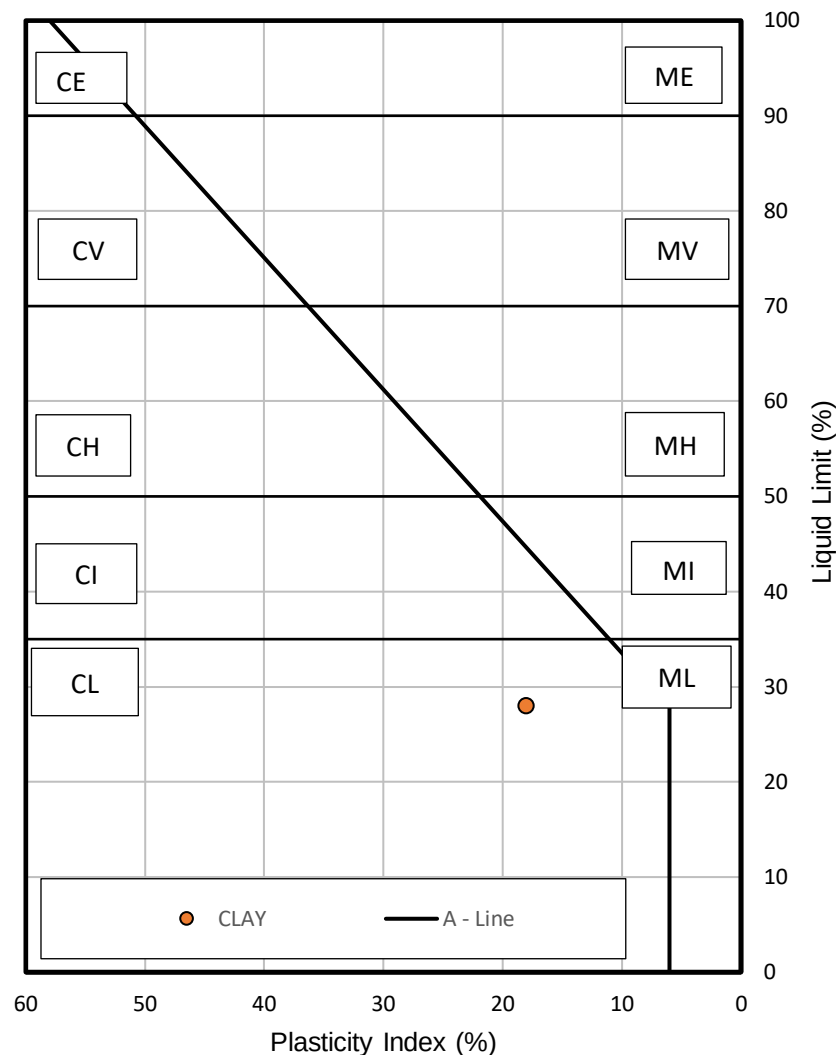


Figure 6: Strength v Depth Plot (Clay and Silt)



An Atterberg Limit test was carried out on one sample of the clay. Results of the test reported a **liquid limit** value of 28% and a **plastic limit** value of 10%, resulting in a value of **plasticity index** of 18%. These results suggest the samples of clay tested are of **low plasticity** as shown on the Plasticity Chart in Figure 7, below.

Figure 7 Plasticity Chart



For design purposes, a value of plasticity index = 18% is recommended, based on the upper quartile of the results.

The **coefficient of volume compressibility (mv)** has been estimated using the following correlation by Stroud and Butler ⁽¹⁹⁷⁵⁾: for a clay with a plasticity index of 18%, $mv = 1 / (0.580 \times N \text{ value})$. This correlation gives values of coefficient of volume compressibility in the range 0.13m²/MN to 0.25m²/MN, as shown in Table 6, above. The results suggest the clay has a **medium compressibility**.

6.3.2 Silt

A clayey sandy gravelly silt was encountered in exploratory hole location WS02 between 2.00 and 3.60m below ground level.

SPT tests carried out in the silt resulted in **SPT N values** of between 6 and 7, as shown on the SPT v Depth Plot in Figure 5 (above). The results suggest the silt is soft.

In-situ **hand penetrometer** (HP) tests taken in the silt have given results of shear strength in the range 48kN/m² to 96kN/m², suggesting the silt is firm to stiff.

Figure 6, above, shows the **shear strength** of the silt soils based on in-situ hand penetrometer tests alongside equivalent shear strength from SPT N values based on correlations by Stroud and Butler⁽¹⁹⁷⁵⁾.

Recommended N values and derived design values for the silt soils are summarised in Table 7, below.

Table 7: Summary of Design Parameters (Silt)

Depth	SPT N Value Range	Average N Value	Design N Value*	Equivalent Shear Strength** (kN/m ²)	Coefficient of Volume Compressibility** (mv)
2.0	6	6	6	27	0.18
3.0	7	7	7	32	0.17
*Based on lower quartile N value and correlations by Peck Hanson and Thornburn ⁽¹⁹⁷⁴⁾					
**Based on correlation by Stroud & Butler ⁽¹⁹⁷⁵⁾					

It is recommended that for assessing ultimate bearing capacities, where the lower values are critical, the lower quartile value of N values is used. Based on the N Values in the above table, the equivalent shear strength values were in the range of 27 - 32kN/m², which equate to silts of low strength based on Table 1.

An Atterberg Limit test was carried out on one sample of the silt. However, the results concluded the sample was non-plastic.

The **coefficient of volume compressibility (mv)** has been estimated using the following correlation by Stroud and Butler⁽¹⁹⁷⁵⁾: for a silt located in WS02 between 2.00m and 3.60m bgl, the correlation gives values of coefficient of volume compressibility in the range 0.17m²/MN to 0.18m²/MN, as shown in Table 7, above. The results suggest the silt has a **medium compressibility**.

6.3.3 Sand

Sand was encountered in exploratory hole locations WS01, WS02 and WS03 at depths between 1.50m and 6.00m below ground level.

SPT tests carried out in the sand resulted in **SPT N values** of between 8 and 20, as shown on the SPT v Depth Plot in Figure 5 (above). The results suggest suggests the sand is loose to medium dense.

Recommended N values and derived design values for the granular soils are summarised in Table 8, below.

Table 8: Summary of Design Parameters (Sand)

Depth	SPT N Value Range	Average N Value	Design N Value*	Equivalent Soil Density	Angle of Internal Friction (degrees°)**
2.0	8	8	8	Loose	29
3.0	16	16	16	Medium Dense	32
4.0	14-18	17	16	Medium Dense	32
5.0	9-19	14	11	Medium Dense	30
6.0	12-20	17	16	Medium Dense	32
*Based on lower quartile N value					
**Based on the correlation by Peck, Hanson and Thornburn ⁽¹⁹⁷⁴⁾					

It is recommended that for assessing ultimate bearing capacities, where the lower values are critical, the lower quartile value of N values is used. For design purposes, a value of 8 seems reasonable based on the SPT N values encountered at 2.00m depth.

Based on the correlation by Peck, Hanson and Thornburn ⁽¹⁹⁷⁴⁾, this gives an **angle of shearing resistance** of $\phi=29$ at 2.0m bgl.

For assessing settlements average ground conditions will give a more realistic value of settlements, and the average of N values should be used.

7.0 GEOTECHNICAL ASSESSMENT

7.1 Proposed Development

It is understood that the client intends to construct a residential development on the site comprising a three storey, end terrace dwelling house. The development will consist of 5no. bedrooms and front and rear gardens. Detailed information regarding structural loadings and proposed foundation type was not available at the time of writing the report.

7.2 Ground Conditions Encountered

The exploratory holes generally encountered Made Ground to a maximum depth of 2.00m bgl (WS02). Underlying the Made Ground in the WS exploratory boreholes were deposits of varying clay, silt, and sand to a maximum depth of 6.00m bgl.

Groundwater was encountered at 2.80m in WS01 and at 2.00 in WS02 during the fieldwork.

7.3 Foundation Considerations

Based on the ground conditions encountered, conventional shallow strip/pad foundations are considered suitable for the proposed development, bearing into the superficial deposits, providing the anticipated structural loadings are relatively low and subject to tolerance of structure to settlement.

Should the allowable bearing pressure and settlement prove unfavourable, then alternative foundations options will need to be considered, such as ground improvement and piles.

The shallow strip/pad foundations are discussed below in 7.3.1.

7.3.1 *Conventional Shallow Depth Strip/Pad Foundations*

Strip/Pad foundations should be taken down below any Made Ground and placed in the superficial deposits beneath at a minimum depth of 2.00m. If any Made Ground, particularly loose or soft material, is encountered at foundation level this should be excavated and replaced with suitable granular fill or the foundation extended at least 150mm into suitable natural strata.

Foundations should be placed in materials of similar bearing and consolidation characteristics to avoid potential differential settlement occurring. Should foundations cross from cohesive to granular soils, nominal reinforcement should be incorporated to avoid the effects of differential settlement. It should be noted that clay, silt, and sand were encountered at shallow foundation depths.

Table 9 overleaf summarises anticipated allowable bearing pressures for strip/pad foundations placed in the superficial deposits. The bearing capacities are calculated based on Hansen's ⁽¹⁹⁷⁸⁾ method and assuming a factor of safety against bearing capacity failure of 3. For the purpose of the calculation, groundwater has been assumed to be at foundation level.

Table 9: Summary of Allowable Bearing Pressures

Foundation Strata	Design Value (Section 6)	Foundation Depth (m bgl)	Foundation Type	Foundation Size (m)	Allowable Bearing Pressure (kN/m ²)
CLAY	$c_u=32\text{kN/m}^2$	2.0	Strip	0.4	90
				0.9	86
			Pad	1.0 x 1.0	100
	$c_u=32\text{kN/m}^2$	2.5	Strip	0.4	93
				0.9	89
			Pad	1.0 x 1.0	104
SILT	$c_u=27\text{kN/m}^2$	2.0	Strip	0.4	77
				0.9	73
			Pad	1.0 x 1.0	85
	$c_u=27\text{kN/m}^2$	2.5	Strip	0.4	79
				0.9	76
			Pad	1.0 x 1.0	88
SAND	$\phi = 29^\circ$	2.0	Strip	0.4	134
				0.9	137
			Pad	1.0 x 1.0	196
	$\phi = 29^\circ$	2.5	Strip	0.4	166
				0.9	169
			Pad	1.0 x 1.0	246
				2.0 x 2.0	242

Table 10 overleaf summarises anticipated settlements of the above foundations in clay and silt (cohesive soils) based on design values discussed in Section 6. Settlement in cohesive soils typically comprises a small amount of immediate settlement as loads are applied and a larger proportion of consolidation settlement, which will occur over a longer period. For the purposes of the calculations the strata over the depth of influence of the foundation is assumed as the same type and the foundation loading assumed as equal to the above bearing pressures to give a worse-case scenario.

Table 10: Summary of Anticipated Settlement (Cohesive)

Foundation Depth (m bgl)	Foundation Strata	Foundation Type	Foundation Size (m)	Pad Foundation Loading (kN/m²)	Settlement (mm)		
					At Centre	At Corner	Average
2.0	CLAY	Strip	0.4	90	-	-	5-10
			0.9	86	-	-	10-15
		Pad	1.0 x 1.0	100	20-25	5-10	15-20
			2.0 x 2.0	92	20-25	5-10	15-20
2.5		Strip	0.4	93	-	-	5-10
			0.9	89	-	-	5-10
		Pad	1.0 x 1.0	104	15-20	<5	10-15
			2.0 x 2.0	96	15-20	<5	10-15
2.0	SILT	Strip	0.4	77	-	-	5-10
			0.9	73	-	-	5-10
		Pad	1.0 x 1.0	85	15-20	<5	10-15
			2.0 x 2.0	78	15-20	<5	10-15
2.5		Strip	0.4	79	-	-	5-10
			0.9	76	-	-	5-10
		Pad	1.0 x 1.0	88	15-20	<5	10-15
			2.0 x 2.0	82	10-15	<5	10-15

Table 11 below summarises anticipated settlements of the above foundations (Table 9) in sand based on design values discussed in Section 6. The foundation loading assumed as equal to the above bearing pressures to give a worse-case scenario.

Table 11: Summary of Anticipated Settlement (Granular)

Foundation Depth (m bgl)	Foundation Strata	Foundation Type	Foundation Size (m)	Pad Foundation Loading (kN/m²)	Settlement* (mm)		
					Lower Limit	Upper Limit	Best Estimate
2.0	SAND	Strip	0.4	134	<5	30-35	5-10
			0.9	137	5-10	55-60	15-20
		Pad	1.0 x 1.0	196	5-10	55-60	15-20
			2.0 x 2.0	193	10-15	90-95	25-30
2.5		Strip	0.4	166	5-10	40-45	10-15
			0.9	169	10-15	70-75	20-25
		Pad	1.0 x 1.0	246	10-15	70-75	20-25
			2.0 x 2.0	242	15-20	110-115	30-35
*Immediate settlement							

Floor slabs should be designed as suspended if Made Ground of 600mm thickness or greater is present. Made ground is not considered an appropriate bearing stratum due to its variable nature. Floor slabs may be designed as ground bearing where Made Ground is excavated and replaced with suitable granular fill.

7.3.2 Ground Improvement

Ground treatment (e.g., vibro displacement) may be an option, subject to environmental and noise/vibration constraints.

For example, vibro stone columns are often used to solve a wide range of static, dynamic, and seismic foundation problems by using powerful depth vibrators to densify soils of form stone columns that compact or reinforce soils in situ. Vibro systems can be used to treat granular deposits, fills, made ground and soft clays/silts.

Soils treated by vibro could offer an allowable bearing pressure in the range 100kN/m² to 200kN/m², depending on column spacings and ground encountered.

Once the treatment has been carried out, spread foundations may be adopted across the site, and designed to the loadings given above. Providing that any imported fill material between the tops of the columns and the underside of the floor slab is placed in a controlled manner, floor slabs may be ground bearing. Positive assurances should be sought from an experienced specialist contractor that the proprietary system proposed can provide the required working loads in the ground conditions encountered, with a guarantee on maximum settlement for both footings and floor slabs.

7.3.3 Piled Foundations

Proposed buildings may be founded on piles taken down to depth to a suitable founding stratum.

A variety of pile types may be used, including bored and continuous flight auger (CFA) piles. Driven piles may be suitable, subject to environmental and noise/vibration constraints.

Because of the various advantages and limitations of each pile type, and the cost implications, advice should be sought from specialist piling contractors to determine the most suitable and cost-effective type. They should also be able to give recommended pile diameters and depths and likely pile capacities, with guaranteed performance. It is recommended a pile test be carried out to confirm pile capacities. In assessing the pile capacities, contractors should make an allowance for the effects of negative skin friction, particularly in the made ground and soft clays.

There may be differential settlement between piled structures and the surrounding ground level. Provision should, therefore, be made to make up ground levels at threshold positions, loading bays, vehicle access doorways, etc. Alternatively, these materials should be removed and replaced in a controlled manner by suitable existing materials or imported engineered fill.

It is essential the advice of a specialist piling contractor is sought and that positive assurances are provided by the piling contractor that their proprietary system can provide the required working loads in the ground conditions encountered.

7.4 Pavement Design

The ground investigation identified the soil type at the subgrade level to typically be Made Ground.

A conservative design CBR value of 1% should be adopted in areas where Made Ground is encountered at subgrade level.

Based on the recommendations for design CBR values provided in Interim advice note 73/06, Revision 1 (2009), CBR values of up to 20% may be encountered in the natural superficial deposits.

Consideration should be given to the potential differing ground conditions near surface, which could cause pavements to be constructed on variable made ground. In this context a flexible pavement design may be required.

Consideration should also be given to the use of geotextiles to allow reduction of capping thickness. For examples biaxial geogrids such as Tensar SSLA20 and SSLA30 are often used to reduce capping thickness. The advice of a suitable contractor should be sought as to the most appropriate type of geotextile to use in the ground conditions encountered at this site. For

guidance, the following table gives a comparison of granular layer thickness with and without the use of a geotextile, in accordance with the requirement of HA25/94 Part 2.

It should be noted the type of construction will depend on proposed finished pavement levels across the site and it is recommended the pavement design is reviewed once these levels are known. In this context, it is essential further in situ CBR testing is carried out once formation levels are known to confirm design CBR values.

Table 12: Comparison of Capping Thickness with and without Geotextile

CBR	Unreinforced			Reinforced with Tensar Geogrid				
	Sub-base	Capping	Total	Sub-base	Capping	No. of grids	Total	Thickness saving
0.5%	Design not suitable			200mm	400mm	2	600mm	-
1.0%	150mm	600mm	750mm	400mm	0	1	400mm	350mm
1.5%	150mm	600mm	750mm	310mm	0	1	310mm	440mm
2.0%	150mm	600mm	750mm	260mm	0	1	260mm	490mm
3.0%	150mm	350mm	500mm	210mm	0	1	210mm	290mm
4.0%	150mm	300mm	450mm	175mm	0	1	175mm	275mm
5.0%	150mm	250mm	400mm	160mm	0	1	160mm	240mm
These figures are suitable for light access roads and car parks, based on 1000 standard axles. For heavier loaded pavements the advice of specialist contractor should be sought.								

All formation excavations should be examined by a suitably experienced engineer or inspector to check for soft or unsuitable material, which should be removed and replaced with compacted granular fill. Also, to ensure good compaction and remove unevenness, the formation should be compacted with equipment suitable for use in the ground conditions encountered. Careful inspection of this work will also help identify any soft spots at or just below formation level.

7.5 Permeability Testing

Falling head testing has been conducted within three monitoring installations across the site, in accordance with the methods described in BS5930 (Code of Practice for Site Investigations).

Measured infiltration rates determined across the site are presented in Table 13 below and presented in full in Appendix 2.

Table 13: Results of Falling Head Testing

Location/Test	Test No.	Test Duration (secs)	Infiltration Rate (metres/s)
WS01	Test 1	2100	9.93E-07
	Test 2	2100	1.17E-06
	Test 3	2400	1.66E-06
WS02	Test 1	3000	8.93E-07
	Test 2	3000	8.93E-07
	Test 3	3000	6.94E-07
WS03	Test 1	1500	1.40E-06
	Test 2	1500	1.40E-06
	Test 3	1800	1.40E-06

7.6 Chemical Attack on Buried Concrete

Chemical tests (see Appendices) show low levels of water-soluble sulphates and near neutral conditions. Based on these conditions, it is recommended that for concrete placed in natural strata the Design Sulphate Class for the site, as defined in BRE Special Digest 1⁽²⁰⁰⁵⁾, be taken as DS-1, and the Aggressive Chemical Environment for Concrete (ACEC) site classification be taken as AC-1s. The recommendations of BRE Special Digest 1 should be followed for concrete foundations and ground bearing floor slabs.

7.7 Suitability of Excavated Materials

Acceptability criteria and testing, and methods of compaction/placement will depend on the type of contract and specification used for the construction of the proposed development and it is recommended that earthworks specifications are reviewed by a suitably qualified engineer once these have been prepared by the relevant parties.

Granular Made Ground and natural sand/gravel could be suitable for re-use as structural fill, providing it is not contaminated and does not contain excessive amounts of clay and providing moisture contents are controlled during placement. The control of moisture contents will be important as the cohesive content of this stratum is likely to be sensitive to moisture content changes.

7.8 Temporary Works

Formations will be susceptible to damage both by weather and trafficking, and should be protected immediately on exposure, particularly in areas where construction plant will access the site.

Excavations in Made Ground are likely to be unstable and should be battered back to an angle of 1 in 2, or a system of close sheeting and shoring adopted to ensure stability, and where personnel are required to enter excavations. All excavations should be adequately supported where personnel are required to enter.

Groundwater seepages could be encountered near surface within excavations, particularly during the wetter months of the year. Pumping of excavations from a suitable located sump is likely to be required to keep excavations dry.

All-natural materials on site should be capable of being excavated using conventional excavating machinery.

8.0 SOIL CONTAMINATION RISK ASSESSMENT

8.1 Tier I Human Health Soil Risk Assessment – Groundworkers During Development

To assess the risk of soil contamination to construction and ground workers during development, guidelines from the HSE Document 'Protection of workers and the public during development of contaminated land' ⁽¹⁹⁹¹⁾ are used. The document assesses soil contamination test results and classifies the site as being uncontaminated or contaminated with varying degrees of contamination from 'slight' to 'unusually heavy'. The guideline values and laboratory test results are summarised in the following table:

Table 14: Summary of Guideline Values for Protection of Workers and the General Public During Development of Contaminated Land

Contaminant	Typical Values* for:					Test Results	Class
	Uncontaminated Soils	Slight Contamination	Contaminated	Heavy Contamination	Unusually Heavy Contamination		
	Class A	Class B	Class C	Class D	Class E		
pH (alkaline)	7 - 8	8 - 9	9 - 10	10 - 12	12	7.1 - 8.2	A - B
Arsenic	0 - 30	30 - 50	50 - 100	100 - 500	500	7 - 8	A
Cadmium	0 - 1	1 - 3	3 - 10	10 - 50	50	< 0.2 - 0.2	A
Chromium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	9 - 13	A
Copper	0 - 100	100 - 200	200 - 500	500 - 2500	2500	12 - 15	A
Lead	0 - 500	500 - 1000	1000 - 2000	2000 - 1%	1.0%	45 - 106	A
Mercury	0 - 1	1 - 3	3 - 10	10 - 50	50	< 1	A
Nickel	0 - 20	20 - 50	50 - 200	200 - 1000	1000	5 - 9	A
Zinc	0 - 250	250 - 500	500 - 1000	1000 - 5000	5000	49 - 97	A
Boron	0 - 2	2 - 5	5 - 50	50 - 250	250	< 1	A
Selenium	0 - 1	1 - 3	3 - 10	10 - 50	50	< 3	A
Barium	0-500	500-1000	1000-2000	2000-1.0%	1.0%	106 - 169	A
Beryllium	0 - 5	5 - 10	10 - 20	20 - 50	50	< 0.5 - 0.6	A
Vanadium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	15 - 22	A
Sulphate	0 - 2000	2000 - 5000	5000 - 1%	1% - 5%	5.05%	820 - 889	A
Sulphide	0 - 10	10 - 20	20 - 100	100 - 500	500	< 5	A
Cyanide (free)	0 - 1	1 - 5	5 - 50	50 - 100	100	< 2	A
Phenol	0 - 2	2 - 5	5 - 50	50 - 250	250	< 2	A

Based on the above results the soils are predominantly uncontaminated with only a slight contamination in pH (alkaline).

Therefore, there is a **LOW** potential risk from soil contamination to construction workers, ground workers and members of the public during construction. Appropriate measures, such as PPE, site health plans, and appropriate disposal of material arisings will be required to mitigate this risk.

8.2 Tier I Human Health Soil Risk Assessment – Future Site Users

The following section provides a Human Health Soil Assessment for future site users. Based on the proposed development type, the following section compares the results of contamination analyses to residential types of end development as specified by Defra/LQM/CIEH. As part of the contamination assessment, the chemical results obtained by EEG have been screened against accepted compliance criteria, namely:

- Defra C4SL Health Criteria Values (March 2014), where available; and

- Tier 1 assessment values - based on LQM/CIEH Suitable 4 Use Levels ⁽²⁰¹⁵⁾ (S4ULs).

The soil chemical testing results are summarised in Table 15, below.

Table 15: Soil Results Comparison with C4SL/S4UL Values

Parameter	C4SL/S4UL Levels Residential End Use (mg/kg)	WS01 0.25m	WS03 1.00m	No. of Exceedances
		MG*	MG*	
Metals				
Arsenic	37	8	7	0
Boron	290	< 1	< 1	0
Cadmium	22	0.2	< 0.2	0
Chromium III	910	9	13	0
Chromium VI	21	< 2	< 2	0
Copper	2400	15	12	0
Lead	200	106	45	0
Inorganic Mercury	1.2	< 1	< 1	0
Nickel	180	5	9	0
Selenium	250	< 3	< 3	0
Vanadium	410	15	22	0
Zinc	3700	97	49	0
Total Petroleum Hydrocarbons				
Benzene	0.087	<0.002	<0.002	0
Toluene	130	<0.005	<0.005	0
Ethylbenzene	47	<0.002	<0.002	0
o-xylenes	60	<0.002	<0.002	0
m-xylenes	59	<0.002	<0.002	0
p-xylenes	56	<0.002	<0.002	0
Aliphatic EC >5-6	42	< 0.01	< 0.01	0
Aliphatic EC >6-8	100	< 0.05	< 0.05	0
Aliphatic EC >8-10	27	< 2	< 2	0
Aliphatic EC >10-12	130	< 2	< 2	0
Aliphatic EC >12-16	1100	< 3	< 3	0
Aliphatic EC >16-21	65000	< 3	< 3	0
Aliphatic EC >21-35	65000	< 10	< 10	0
Aromatic EC >5-7	70	< 0.01	< 0.01	0
Aromatic EC >7-8	130	< 0.05	< 0.05	0
Aromatic EC >8-10	34	4	< 2	0
Aromatic EC >10-12	74	3	< 2	0
Aromatic EC >12-16	140	8	< 2	0
Aromatic EC >16-21	260	35	< 3	0
Aromatic EC >21-35	1100	75	< 10	0
Polycyclic Aromatic Hydrocarbons				
Naphthalene	2.3	0.61	< 0.1	0
Acenaphthylene	210	< 0.1	< 0.1	0
Acenaphthene	170	1.10	< 0.1	0
Fluorene	170	0.71	< 0.1	0
Phenanthrene	95	4.84	< 0.1	0
Anthracene	2400	1.07	< 0.1	0
Fluoranthene	280	6.11	0.26	0
Pyrene	620	5.37	0.22	0
Benzo(a)anthracene	7.2	2.55	0.25	0
Chrysene	15	2.33	< 0.1	0
Benzo(a)pyrene	5	1.87	0.16	0
Benzo(b)fluoranthene	2.6	2.73	0.32	1
Benzo(k)fluoranthene	77	0.81	< 0.1	0
Indeno(1,2,3-cd) pyrene	27	1.34	0.32	0
Dibenz (a, h) anthracene	0.24	0.16	< 0.1	0
Benzo(ghi)perylene	320	1.05	0.14	0
Phenols				
Phenol	280	< 2	< 2	0
*MG = Made Ground Concentrations in red are above the assessment criteria based on Residential End Use with Plant Uptake.				

Based on the above table, one contaminant concentration was found in exceedance of the screening criteria relevant to a Residential End Use.

The contaminant Benzo(b)fluoranthene was identified in WS01 at 0.25m.

Asbestos was not identified any of the samples collected.

8.3 Soil Waste Assessment

An assessment of the disposal characteristics of the soil in accordance with Environment Agency guidance WM3.1, edition of June 2018, "Guidance on the classification and assessment of waste" has been carried out on soils recovered from the site, using HazWasteOnline.

The results are summarised in Table 16 below and presented in full in Appendix 5.

Table 16: Waste Classification of Soils

Location	Depth (m bgl)	WM3.1 Classification	Comments
WS01	0.25	Non - Hazardous	-
WS03	1.00	Non - Hazardous	-

Table 16 above shows that the two soil samples collected from the window sample boreholes were classified as **Non-Hazardous** in accordance with WM3.1.

Further Waste Acceptance Criteria (WAC) testing may prove that this material is acceptable as inert waste.

9.0 CONCLUSIONS & RECOMMENDATIONS

9.1 Soil Contamination

There is a low potential risk from soil contamination to construction workers and ground workers during development, and appropriate measures such as PPE, site health plans, appropriate disposal of material arisings will be required to mitigate this risk. The groundworks contractor must provide a soil management plan including methods of dealing with unanticipated soil contamination encountered during groundworks.

Based on the results of the chemical testing, one marginal exceedance in Benzo(b)fluoranthene was observed in the soil samples analysed. The contaminant exceedance was located in WS01.

However, the contaminated soil is located beneath the proposed building footprint. Therefore, there will be a low risk, due to the removal of the pollutant linkage during development.

9.2 Foundations

Shallow strip/pad foundation placed in the superficial deposits at a minimum depth of approximately 2.0m bgl are considered appropriate for the proposed development.

As cohesive to granular soils were encountered at foundation depth, nominal reinforcement should be incorporated to avoid the effects of differential settlement.

Should the allowable bearing pressure and settlement prove unfavourable, then alternative foundations options will need to be considered.

There were no existing foundations identified in foundation pits (TP01 and TP02).

9.3 Soil Disposal

Soils should be disposed of at a suitable site, registered to take the levels of contamination encountered. The soils collected from all borehole locations have been classified as Non-Hazardous (See Table 16) for the purpose of off-site disposal in accordance with Environment Agency guidance WM3.1.

Further Waste Acceptance Criteria testing may prove that all these materials are acceptable as inert waste.

9.4 Soakaways/Soil Permeability

The infiltration rates determined from the falling head testing carried out on site suggest that soakaways are not feasible for the site.

9.5 Risk to Buried (Water) Services

It is considered that, due to the absence of any significant hydrocarbon, VOC and BTEX contamination, standard materials should be acceptable for new water pipes. Further advice should be sought from the local water company.

Previous guidance on buried water pipes was contained in Water Regulations Advisory Scheme (WRAS) Guidance Note No. 9-04-03⁽²⁰⁰²⁾, however this has been superseded by the UK Water

Industry Research Report 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites' Ref 10/WM/03/21 (January 2011).

9.6 Site Personnel

As with all construction sites, personnel working on the site during the construction period should be encouraged to maintain a high standard of personal hygiene and on-site washing facilities should be available.

9.7 Other Matters

Due diligence is required during the construction period, and should any further evidence of contamination be found, appropriate investigation and / or action should be taken. The significance of any contamination not discovered by this investigation is outside the scope of this report.

APPENDIX 1

EXPLORATORY HOLE LOGS

APPENDIX 2

FALLING HEAD TESTING RESULTS

APPENDIX 3

GEOTECHNICAL TESTING RESULTS

APPENDIX 4

CHEMICAL TESTING RESULTS

APPENDIX 5

SOIL WASTE ASSESSMENT

APPENDIX 6

REPORT LIMITATIONS

REPORT LIMITATIONS

This contract was completed by Earth Environmental & Geotechnical Ltd based on a defined programme and scope of works and terms and conditions agreed with the client. This report was compiled with all reasonable skill, and care, bearing in mind the project objectives, the agreed scope of works, the prevailing site conditions, the budget, and staff resources allocated to the project.

Other than that, expressly contained in the above paragraph, Earth Environmental & Geotechnical Ltd provides no other representation or warranty whether express or implied, is made in relation to the services. Unless otherwise agreed this report has been prepared exclusively for the use and reliance of the client in accordance with generally accepted consulting practices and for the intended purposes as stated in the agreement under which this work was completed. This report may not be relied upon, or transferred to, by any other party without the written agreement of a Director of Earth Environmental & Geotechnical Ltd.

If a third party relies on this report, it does so wholly at its own and sole risk and Earth Environmental & Geotechnical Ltd disclaims any liability to such parties.

It is Earth Environmental & Geotechnical Ltd understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was an important factor in determining the scope and level of the services. Should the purpose for which the report is used, or the proposed use of the site change, this report will no longer be valid and any further use of, or reliance upon the report in those circumstances by the client without Earth Environmental & Geotechnical Ltd review and advice shall be at the client's sole and own risk.

The report was written in 2021 and should be read considering any subsequent changes in legislation, statutory requirements, and industry best practices. Ground conditions can also change over time and further investigations, or assessment should be made if there is any significant delay in acting on the findings of this report. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of Earth Environmental & Geotechnical Ltd. In the absence of such written advice of Earth Environmental & Geotechnical Ltd, reliance on the report in the future shall be at the client's own and sole risk. Should Earth Environmental & Geotechnical Ltd be requested to review the report in the future, Earth Environmental & Geotechnical Ltd shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between Earth Environmental & Geotechnical Ltd and the client.

The observations and conclusions described in this report are based solely upon the services that were provided pursuant to the agreement between the client and Earth Environmental & Geotechnical Ltd. Earth Environmental & Geotechnical Ltd has not performed any observations, investigations, studies or testing not specifically set out or mentioned within this report.

Earth Environmental & Geotechnical Ltd is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, Earth Environmental & Geotechnical Ltd did not seek to evaluate the presence on or off the site of electromagnetic fields, lead paint, radon gas or other radioactive materials.

The services are based upon Earth Environmental & Geotechnical Ltd observations of existing physical conditions at the site gained from a walkover survey of the site together with Earth Environmental & Geotechnical Ltd interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The findings and recommendations contained in this report are based in part upon information provided by third parties, and whilst Earth Environmental & Geotechnical Ltd have no reason to doubt the accuracy and that it has been provided in full of those it was requested from, the items relied on have not been verified.

No responsibility can be accepted for errors within third party items presented in this report. Further Earth Environmental & Geotechnical Ltd was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the services. Earth Environmental & Geotechnical Ltd is not liable for any inaccurate information, misrepresentation of data or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to Earth Environmental & Geotechnical Ltd and including the doing of any independent investigation of the information provided to Earth Environmental & Geotechnical Ltd save as otherwise provided in the terms of the contract between the client and Earth Environmental & Geotechnical Ltd.

Where field investigations have been carried out these have been restricted to a level of detail required to achieve the stated objectives of the work. Ground conditions can also be variable and as investigation excavations only allow examination of the ground at discrete locations. The potential exists for ground conditions to be encountered which are different to those considered in this report. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition, chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and Earth Environmental & Geotechnical Ltd] based on an understanding of the available operational and historical information, and it should not be inferred that other chemical species are not present.

The groundwater conditions entered on the exploratory hole records are those observed at the time of investigation. The normal speed of investigation usually does not permit the recording of an equilibrium water level for any one water strike. Moreover, groundwater levels are subject to seasonal variation or changes in local drainage conditions and higher groundwater levels may occur at other times of the year than were recorded during this investigation.

Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan but is (are) used to present the general relative locations of features on, and surrounding, the site.