



EARTH ENVIRONMENTAL
& GEOTECHNICAL

Geotechnical & Environmental Site Investigation

Kingsley Road

Northenden

May 2021

On behalf of

Kingsley Developments Manchester Ltd



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**GEOTECHNICAL &
ENVIRONMENTAL**

SITE INVESTIGATION

KINGSLEY ROAD

NORTHENDEN

Report Ref: A3939/21

MAY 2021

Prepared on Behalf of:

KINGSLEY DEVELOPMENTS MANCHESTER LTD

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1.0 EXECUTIVE SUMMARY

Appointment	A site investigation has been commissioned to examine ground conditions for a proposed residential development (8no. units) at a former laundry located at 19 Kingsley Road, Northenden.
The Investigation	The investigation comprised windowless sample boreholes with associated sampling and in situ testing, laboratory geotechnical and contamination testing.
The Site	The site is located in Northenden, Greater Manchester, approximately 0.5km south of Northenden Town Centre. The approximate National Grid Reference for the centre of the site is SJ 82903 89949 (X: 382903, Y: 389949). The site is underlain by Glaciofluvial Sheet Deposits underlain by the Tarporley Siltstone Formation.
Site History	Historically, the site was agricultural land until it was occupied by a steam laundry by 1910 with two smaller buildings in the southwestern corner of the site. From 1934 an additional two buildings are located in the south of the site, changing in size and shape through to 1981. From 1992, the buildings on site were unspecified.
Ground Conditions Encountered	The exploratory holes encountered Made Ground to a maximum depth of 2.00m bgl (WS06). Underlying the Made Ground were deposits of clayey gravelly sand and gravelly sand to a maximum depth of 6.00m bgl. There were also deposits of a sandy gravelly clay and a sandy clay to a maximum depth of 5.00m bgl. A shallow groundwater table has been identified supported largely by a sand horizon underlain by an impermeable clay.
Geotechnical Assessment	Shallow strip/pad foundations should be placed in superficial deposits at a minimum depth of approximately 0.9m bgl. In areas of deep made ground foundations would need to be placed in competent strata which may be close to the water table. Pavement Design – preliminary design value = 1% in Made Ground, up to 20% in natural sand. Design Sulphate Class = DS-1 ACEC Site Classification = AC-1s
Contamination Assessment	Chlorinated solvents have been identified in shallow soils and groundwater. These pose a risk to future end users unless some form of remediation is implemented. A remediation strategy will need to be developed which addresses the adopted remedial option and validation process. As part of the development of the remediation strategy a further site investigation should be conducted after the demolition of the existing structures.

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.

2.0 INTRODUCTION

2.1 Background

A Site Investigation has been commissioned by Kingsley Developments Manchester Ltd to examine ground conditions for proposed new residential properties with associated car parking and soft landscaping at a site off Kingsley Road, Northenden.

Part of the site is currently used as a clothing launderette by Northern Laundry Services Ltd. An Environmental Permit (PPC/DC/RM/17/07) is currently held by Northenden Laundry Services Ltd for the dry cleaning of curtains and specialist fabrics.

The licence allows for the use of a Fibromatic machine (installed in 1999) with Perchloroethylene as the cleaning solvent.

Figure 1 shows a historical photograph of part of the former laundry.

Figure 1: Historical Photograph of Laundry



There has been a steam laundry on the site for over 100 years. As the laundry element of business shrank, parts of the factory were let as industrial units and as of today there is a mixed industrial use on the site.

Planning permission was granted on the 5th March 2021 by Manchester City Council for the erection of 8no dwelling houses comprising of 2no. two storey semi-detached and 6no. three storey terraced townhouses together with associated car parking, landscaping and boundary treatment.

2.2 Previous Investigations

2.2.1 Resource and Environmental Consultants (REC) Ltd, Phase I GeoEnvironmental Assessment (106065p1r1), dated November 2018.

Historical archives show the site to have been first occupied by various parcels of agricultural land until pre-1910, thereafter a steam laundry building occupied most of the northern section of the site with two smaller buildings in the southwestern corner. From 1934 an additional two buildings are located in the south of the site, changing in size and shape through to 1981. From 1992, the buildings on site were unspecified.

Potential sources of contamination were identified as Made Ground from on and off-site development (including an infilled pond located off the site) and contaminants associated with the on-site laundry/dry cleaners including multiple solvents, polychlorinated biphenyls (PCBs) and total petroleum hydrocarbons (TPHs).

An Initial Conceptual Site Model was constructed and the risk to future land users was considered **MODERATE to LOW**. The risk to controlled waters was considered **LOW**.

An intrusive investigation was recommended to confirm the findings of the of the initial conceptual site model and to access the anticipated depths of Made Ground.

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 A3939/21 dated 12th January 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, water and ground gas 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 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 in light of 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

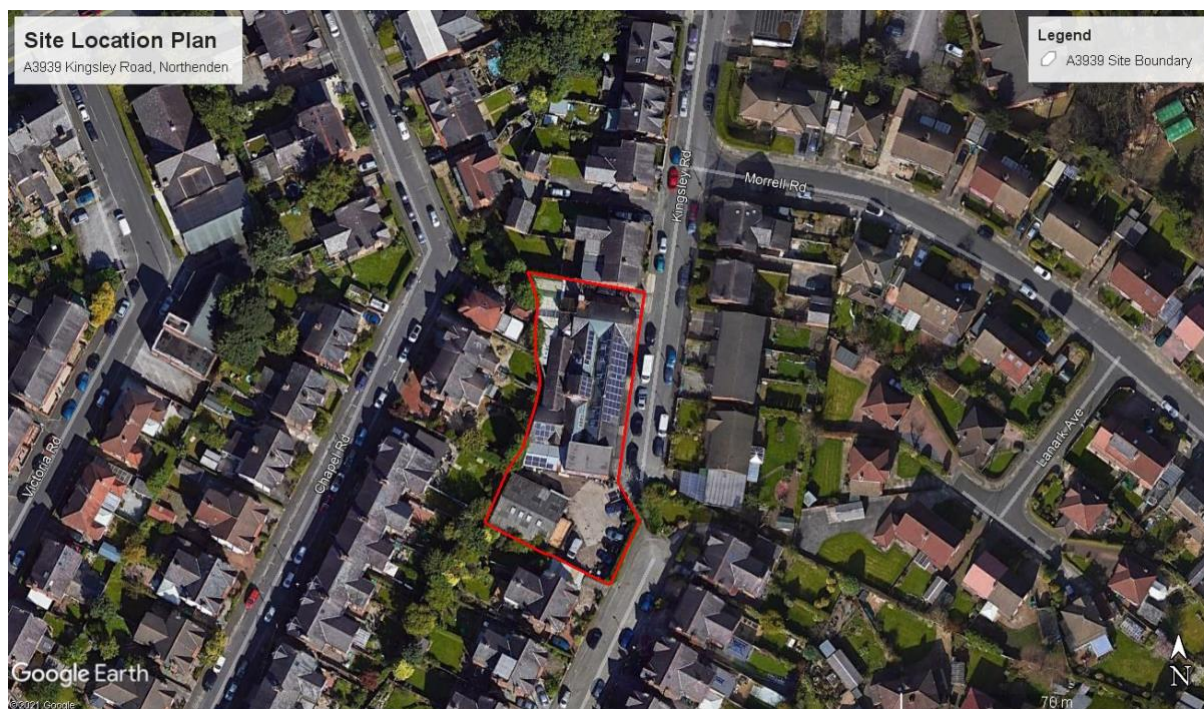
The site is located in Northenden, Greater Manchester approximately 0.5km south of Northenden town centre. The approximate National Grid Reference for the centre of the site is SJ 82903 89949 (X: 382903, Y: 389949) with the closest postcode being M22 4NL.

The site is an irregular shaped parcel of land currently accessible via Kingsley Road to the east of the site. The site is currently occupied by a series of buildings associated with the previous dry cleaners with laundry workshop, several other workshops and offices and a tyre garage. The area of the site is 0.15hectares with a generally flat and level topography.

The general surrounding area comprises predominantly of residential dwellings.

The site location is shown in the aerial photograph presented as Figure 2, below.

Figure 2: Aerial Photograph Showing Site Location



General site photographs are presented in Figure 3 overleaf.

The site currently serves various business tenants ranging from workshops to rent to a Tyre business. The building was first occupied in the late 19th century and served the local community as a laundry for many years.

The site houses a collection of buildings, which have evolved over time, all sprung from the primary red brick one to two storey building facing Kingsley Road.

This building has grown and pushed out to the Western and Northern boundary. Various roof forms can be seen from pitched to flat using slate, metal and plastic. A large chimney also

dominates the site echoing its industrial use. To the southern boundary sits the more recent addition a large industrial unit, circa 1980's.

There is a large parking area in front of the Tyre business on the south end of the site. Parking areas in front of the old laundry building are also used directly of Kingsley Road.

Figure 3: General Site Photographs



Interior of Laundry



Entrance to car repair faciity with external waste oil tank



3.1 Proposed Development

It is understood that the Client intends to build eight residential properties on site with associated soft landscaping and parking. Access will be provided via Kingsley Road and Beech Avenue.

The proposed development layout details are shown in Figure 4 below.

Figure 4: Proposed Development Plan



4.0 SITE INVESTIGATION

4.1 Exploratory Fieldwork

The fieldwork was carried out by EEG on 31st March and 1st April and comprised:

Eight window sample boreholes (designated WS01 to WS08 inclusive) were each sunk to a depth of 4.00m to 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.

50mm diameter standpipes were installed in all window sample boreholes up to a depth of 6.00m below ground level. Installation and backfill details are shown with the appropriate borehole log sheet. EEG carried out groundwater/ground gas monitoring in standpipes after the fieldwork period, the results of which are presented in Appendix 4.

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) in order to locate unrecorded underground services, and the exploratory locations were repositioned if necessary.

A power washer was used to decontaminate the drilling rods and sampling equipment between locations.

A photo ionisation detector (9.8eV lamp) was used to measure the concentration of volatile organic compounds in the headspace of soil samples. Samples were placed in a Teflon bag and after twenty minutes a measurement was taken. The measurements are shown on the borehole logs.

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.

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

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⁾.

Groundwater collection was undertaken using a dedicated Waterra bailer with the sample collected in glass and plastic bottles.

Water levels were monitored by use of an interface meter with a Heron interface meter used measure the thickness of any dense phase hydrocarbons.

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 5, overleaf.

Figure 5: 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	31/03/2021	31/03/2021	382900	389917	SP
WS02	WS	6.00	31/03/2021	31/03/2021	382899	389921	SP
WS03	WS	5.00	31/03/2021	31/03/2021	382911	389923	SP
WS04	WS	5.00	31/03/2021	31/03/2021	382892	389922	SP
WS05	WS	4.00	01/04/2021	01/04/2021	382917	389958	SP
WS06	WS	5.00	01/04/2021	01/04/2021	382901	389942	SP
WS07	WS	4.00	01/04/2021	01/04/2021	382908	389955	SP
WS08	WS	4.00	01/04/2021	01/04/2021	382907	389974	SP

*WS = Window Sample Borehole
 **SP = Standpipe

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, below.

Table 3: Summary of Laboratory Geotechnical Tests Undertaken

TEST	STANDARD	No.
Moisture Content	BS1377:1990 Part 2, Clause 3.2	8
Liquid Limit, Plastic Limit, Plasticity Index	BS1377:1990 Part 2, Clause 4/5	4
Sulphate content of 2:1 soil: water extract	BS1377:1990 Part 3, Clause 5	4
pH value	BS1377:1990 Part 3, Clause 9	4
Triaxial tests		
“Quick” undrained with single stage loading	BS1377:1990 Part 7, Clause 9	4

The results of the laboratory geotechnical tests are discussed in Section 6 and included in Appendix 2.

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 nine 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), Volatile Organic Compounds (VOCs) and Semi-Volatile Organic Compounds (SVOCs)

The results of the laboratory contamination tests are discussed in Section 8 and included in Appendix 3.

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 Tarporley Siltstone Formation, comprising siltstone, mudstone and sandstone. The sequence of strata encountered beneath the site was as follows:

- **Made Ground** – Variable Made Ground was encountered in all the exploratory holes, comprising:
 - Asphalt Hardstanding
 - CONCRETE
 - CONCRETE and REBAR
 - Clayey gravelly SAND (containing gravel of red brick, plastic, clinker, timber, concrete, ash, quartz, mudstone and sandstone with redbrick cobbles in WS06).
 - Gravelly SAND (containing gravel of limestone, redbrick, ash, tarmac, sandstone, metal fixings and concrete)
 - Sandy COBBLES of redbrick.
- **Superficial Deposits** –

Sand was encountered in WS01, WS02, WS03, WS04, WS07 and WS08 comprising:

- Clayey gravelly SAND (containing gravel of quartz, mudstone and sandstone)
- Gravelly SAND (containing gravel of quartz, mudstone and sandstone).

Clay was encountered in all the exploratory holes, comprising:

- Sandy CLAY
- Sandy gravelly CLAY (containing gravel of sandstone and 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 bgl)			GROUNDWATER (m bgl)
	MADE GROUND	SAND	CLAY	
WS01	GL-0.70	0.70-2.80 3.00-3.70 4.00-6.00+	2.80-3.00 3.70-4.00	-
WS02	GL-0.60	0.60-2.60 4.00-6.00+	2.60-4.00	5.00
WS03	GL-0.80	0.80-3.00 4.70-5.00+	3.00-4.70	-
WS04	GL-0.30	0.30-2.20 4.60-5.00+	2.20-4.60	-
WS05	GL-1.90	-	1.90-4.00+	-
WS06	GL-2.00	-	2.00-5.00+	3.00

Hole	Depth to Stratum (m bgl)			GROUNDWATER (m bgl)
	MADE GROUND	SAND	CLAY	
WS07	GL-0.80	0.80-3.70	3.70-4.00+	-
WS08	GL-0.90	0.90-1.60	1.60-4.00+	-

5.2 Observable Indications of Contamination

Gravel of clinker, ash and metal fixings were encountered within the Made Ground of WS04, WS06 and WS08.

5.3 Obstructions

No man-made obstructions were encountered in any of the exploratory hole locations.

5.4 Groundwater

Groundwater was encountered in boreholes WS02 and WS06 during the fieldwork at depths of 5.00m and 3.00m bgl.

5.5 Land Gas

Ground gas monitoring was undertaken using a Geotechnical Instruments G5000 in accordance with the monitoring protocol outlined in CIRIA C665.

Results obtained during four monitoring visits on the 9th, 15th, 22nd and 29th April 2021 indicate methane (CH₄) levels to a maximum of 0.0% by volume, carbon dioxide (CO₂) levels ranging from 0.1% to 6.3% by volume, and oxygen (O₂) levels ranging from 14.1% to 20.6% by volume. Gas flows of -0.1l/hr to 0.0l/hr were recorded, together with atmospheric pressures of between 1009 and 1031mb.

It should be noted that the concentrations and levels of mobile liquid and gaseous materials are likely to vary with time. The results obtained may therefore be representative of the conditions only at the time of sampling.

Gas monitoring results are discussed further in Section 10 and presented in Appendix 4.

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	3.00	Clay	12	30	12	18	-	-	-	-	-	-	-	-	-	-
WS02	2.30	Sand	-	-	-	-	-	-	-	-	-	-	-	-	7.0	220
WS02	3.30 - 3.60	Clay	17	-	-	-	-	-	-	-	-	2.22	1.91	121	-	-
WS03	3.45 - 3.60	Clay	15	34	12	22	-	-	-	-	-	-	-	-	-	-
WS04	3.30 - 3.60	Clay	10	29	10	19	-	-	-	-	-	-	-	-	-	-
WS05	3.70 - 4.00	Clay	18	-	-	-	-	-	-	-	-	2.23	1.90	133	-	-
WS06	2.00	Clay	-	-	-	-	-	-	-	-	-	-	-	-	7.0	200
WS06	3.60 - 3.90	Clay	18	-	-	-	-	-	-	-	-	2.26	1.92	100	-	-
WS07	1.40	Sand	-	-	-	-	-	-	-	-	-	-	-	-	7.0	170
WS07	3.80 - 4.00	Clay	20	31	12	19	-	-	-	-	-	-	-	-	-	-
WS08	1.00	Sand	-	-	-	-	-	-	-	-	-	-	-	-	7.0	120
WS08	3.70 - 4.00	Clay	16	-	-	-	-	-	-	-	-	2.13	1.84	137	-	-

6.2 Made Ground

Made Ground was encountered in all exploratory hole locations between ground level and 2.00m below ground level (WS06) and varied from exploratory hole location.

SPT tests carried out in the deeper Made Ground resulted in **SPT N values** of 13 and 16, as shown on the SPT v Depth Plot, in Figure 6 (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 a clayey gravelly SAND, gravelly SAND, sandy CLAY and sandy gravelly CLAY.

6.3.1 Clay

A sandy gravelly clay was encountered in all exploratory hole locations between 1.60 and 5.00m below ground level except in WS01 where the clay was encountered as sandy clay between 2.80 and 4.00m.

Laboratory testing has given a value of **water-soluble sulphate** of 200mg/l, together with **pH Value** of 7.0.

SPT tests carried out in the clay resulted in **SPT N values** of between 14 and 50, as shown on the SPT v Depth Plot in Figure 6 (overleaf). The results suggest the clay is firm to very stiff.

In-situ **hand penetrometer** (HP) tests have given results of shear strength in the range 108kN/m² to >215kN/m², also suggesting the clay is stiff to very stiff.

The **undrained shear strength** in triaxial compression was carried out on four samples of the clay. Results of the test showed shear strength in the range of 100kN/m² to 137kN/m², suggesting the Clay is High Strength to Very High Strength, in accordance with Table 1.

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 cohesive 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	15 - 38	25	18	81	0.11
3.0	18 - 34	24	19	86	0.10
4.0	14 - 50	31	22	98	0.08
5.0	50	50	50	225	0.04
*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 81 - 225kN/m².

Figure 6: SPT v Depth Plot

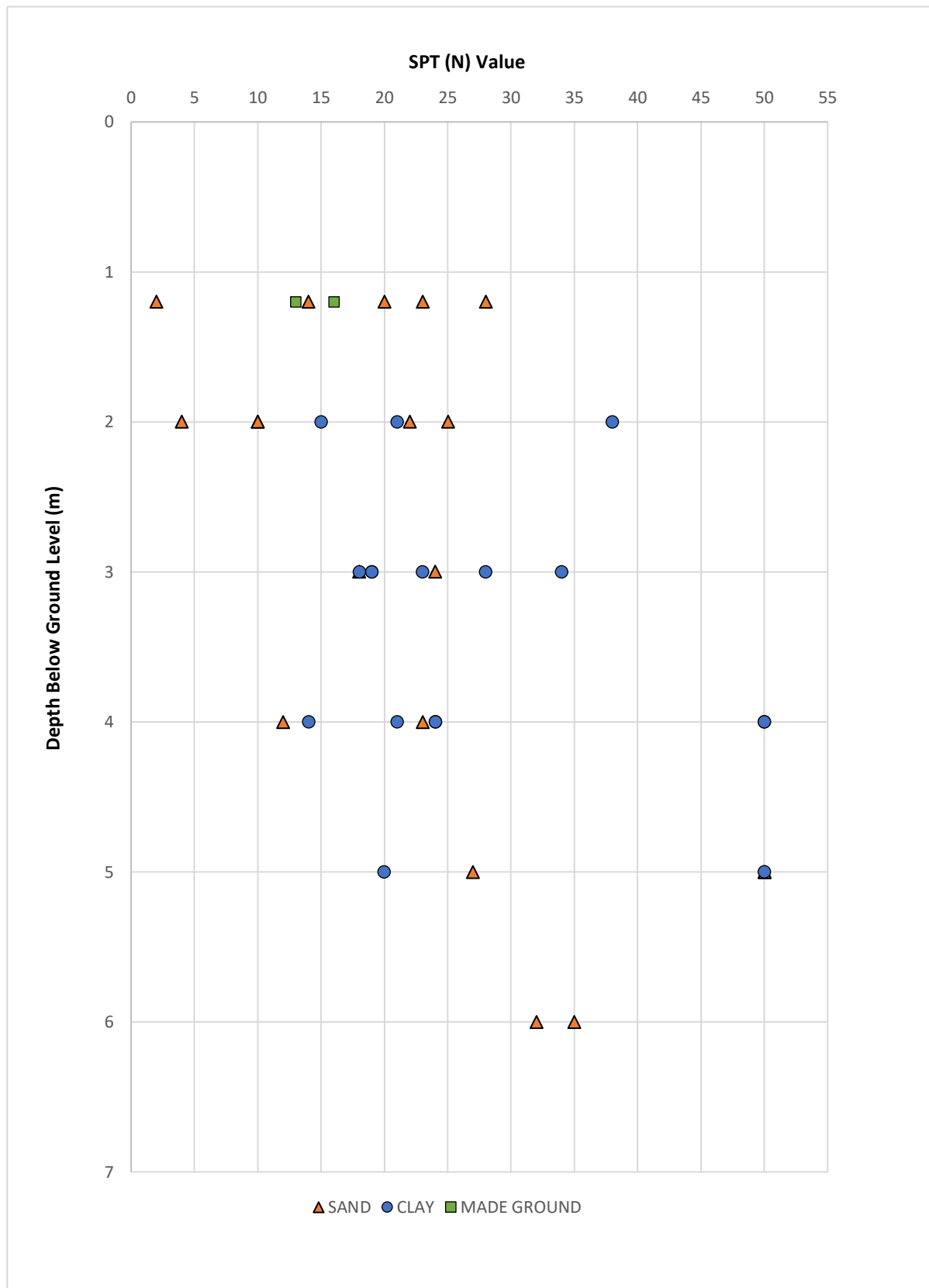
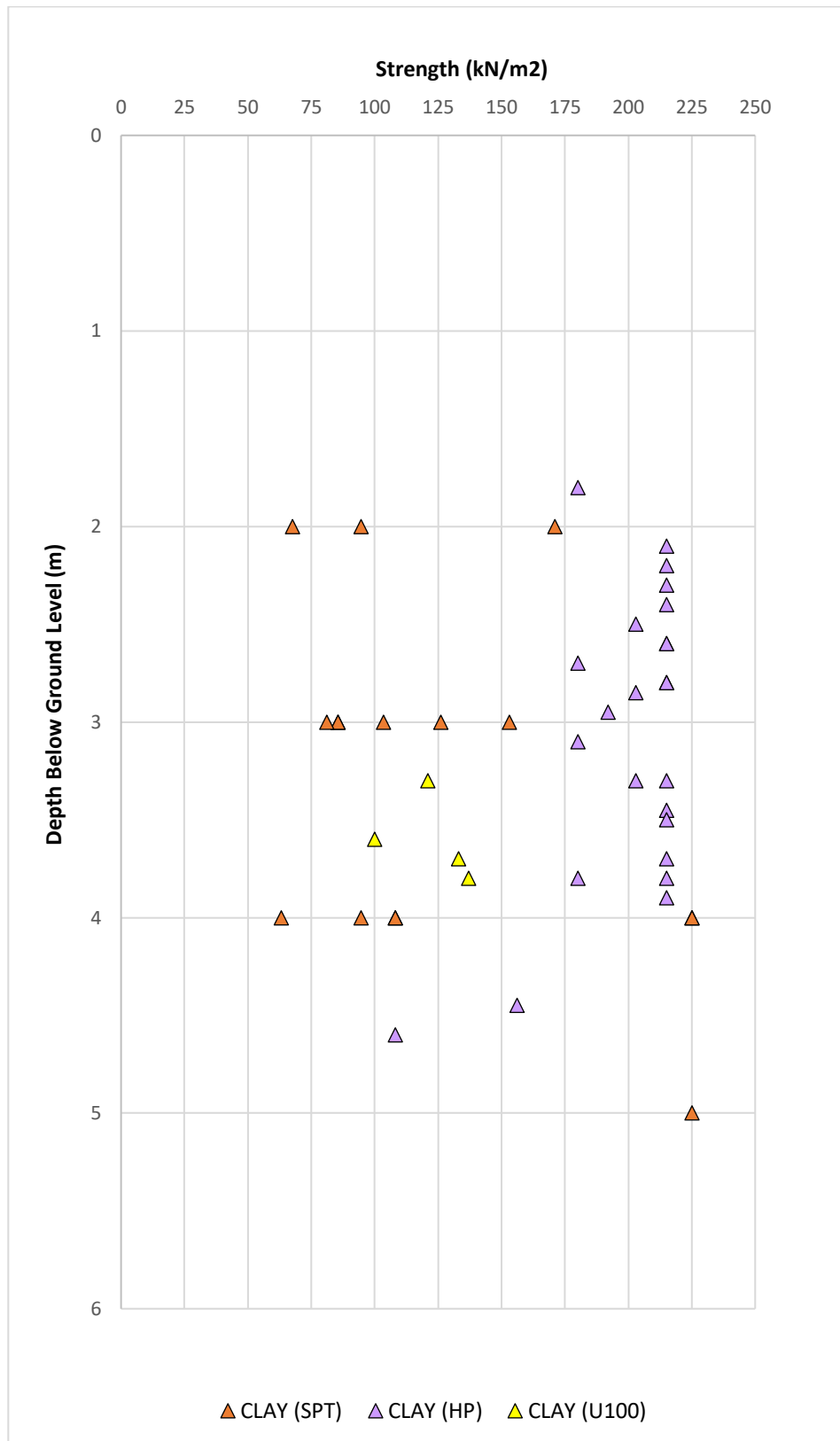
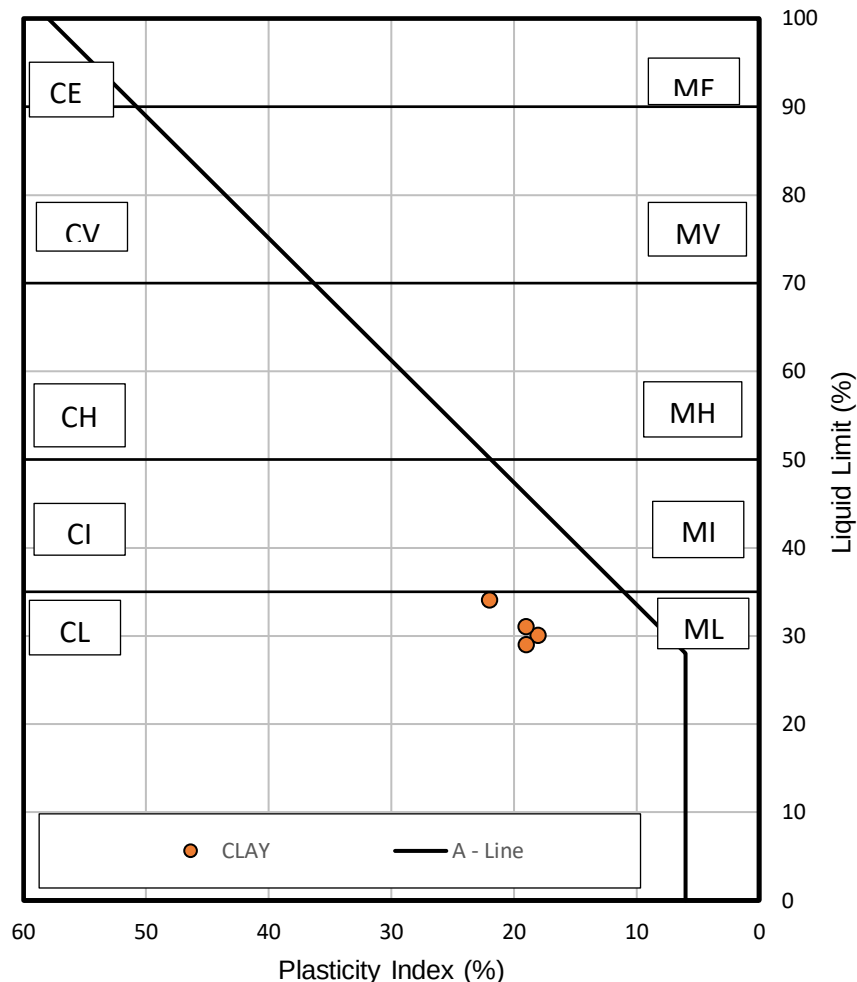


Figure 7: Strength v Depth Plot (Clay)



Atterberg Limit tests were carried out on four samples of the clay. Results of the test reported **liquid limit** values in the range 29% to 34% and **plastic limit** values in the range 10% to 12%, resulting in values of **plasticity index** in the range 18% to 22%. These results suggest the samples of clay tested are of **low to medium plasticity** as shown on the Plasticity Chart in Figure 8, below.

Figure 8 Plasticity Chart



For design purposes, a value of plasticity index = 21% 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 21%, $mv = 1 / (0.525 \times N \text{ value})$. This correlation gives values of coefficient of volume compressibility in the range 0.04m²/MN to 0.11m²/MN, as shown in Table 6, above. The results suggest the clay has a **very low to medium compressibility**.

In accordance with NHBC Chapter 4.2 Building Near Trees ⁽²⁰⁰³⁾ soils can be classified in terms of volume change potential, using the relationship:

$$I'_p = I_p \times \frac{\% \text{ less than } 425\mu\text{m}}{100\%}$$

I'_p = modified plasticity index,

I_p = plasticity index.

Based on the laboratory test results, the above relationship and Table 1 of NHBC Chapter 4.2, the samples of Clay are shown to have **low to medium volume change potential**.

6.3.2 Sand

Sand was encountered in exploratory hole locations WS01, WS02, WS03, WS04, WS07 and WS08 at depths between 0.30m and 6.00m below ground level.

SPT tests carried out in the sand resulted in **SPT N values** of between 2 and 50, as shown on the SPT v Depth Plot in Figure 6 (above). The results suggest the sand is very loose to very dense.

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

Table 7: Summary of Design Parameters (Sand)

Depth	SPT N Value Range	Average N Value	Design N Value*	Equivalent Soil Density	Angle of Internal Friction (degrees°)**
1.2	2 - 28	19	16	Very Loose - Medium Dense	33
2.0	4 - 25	14	10	Loose - Medium Dense	31
3.0	18 - 24	21	20	Medium Dense	33
4.0	12 - 23	18	15	Medium Dense	33
5.0	20 - 50	32	24	Medium Dense - Dense	36
6.0	32 - 35	34	33	Dense	37
*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 10 seems reasonable based on the SPT N values encountered at 2.0m depth.

Based on the correlation by Peck, Hanson and Thornburn⁽¹⁹⁷⁴⁾, this gives an **angle of shearing resistance** of $\phi=31$.

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 build eight new residential properties on site with associated soft landscaping and parking. Access will be provided via Kingsley Road and Beech Avenue, both to the east of the site. Detailed information regarding structural loadings and proposed foundation type was not available, however, we anticipate the loadings to be similar to those of a typical two-storey house (50kN/m² to 75kN/m²).

7.2 Ground Conditions Encountered

The exploratory holes generally encountered Made Ground to a maximum depth of 2.00m bgl (WS06). Underlying the Made Ground in WS01, WS02, WS03, WS04, WS07 and WS08 were deposits of clayey gravelly sand and gravelly sand to a maximum depth of 6.00m bgl. In all exploratory holes, underlying the Made Ground was a sandy gravelly clay and a sandy clay to a maximum depth of 5.00m bgl.

Groundwater was encountered at 5.00m in WS02 and 3.00m in WS06 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 1.50m. 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.

Table 8 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. Due to the variable water level encountered in the monitoring wells, for the purpose of the calculation, groundwater has been assumed to be at foundation level.

Table 8: 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	$c_u=81\text{kN/m}^2$	2.0	Strip	0.4	221
				0.9	208
			Pad	1.0 x 1.0	245
				2.0 x 2.0	223
	$c_u=81\text{kN/m}^2$	2.5	Strip	0.4	224
				0.9	214
			Pad	1.0 x 1.0	194
				2.0 x 2.0	179
SAND	$\phi = 33^\circ$	1.0	Strip	0.4	108
				0.9	118
			Pad	1.0 x 1.0	163
				2.0 x 2.0	172
	$\phi = 33^\circ$	1.5	Strip	0.4	158
				0.9	167
			Pad	1.0 x 1.0	243
				2.0 x 2.0	247
	$\phi = 31^\circ$	2.0	Strip	0.4	167
				0.9	172
			Pad	1.0 x 1.0	252
				2.0 x 2.0	250
	$\phi = 31^\circ$	2.5	Strip	0.4	207
				0.9	213
			Pad	1.0 x 1.0	316
				2.0 x 2.0	312

Table 9 below summarises anticipated settlements of the above foundations in clay 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 of time. 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 9: 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	221	-	-	10-15
			0.9	208	-	-	10-15
		Pad	1.0 x 1.0	245	20-25	5-10	15-20
			2.0 x 2.0	223	25-30	5-10	20-25
2.5		Strip	0.4	224	-	-	5-10
			0.9	214	-	-	10-15
		Pad	1.0 x 1.0	194	10-15	<5	5-10
			2.0 x 2.0	179	15-20	<5	10-15

Table 10 overleaf summarises anticipated settlements of the above foundations in sand/gravel 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 10: 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
1.0	SAND	Strip	0.4	108	<5	5-10	<5
			0.9	118	<5	15-20	<5
		Pad	1.0 x 1.0	163	<5	15-20	5-10
			2.0 x 2.0	172	<5	25-30	5-10
1.5		Strip	0.4	158	<5	10-15	<5
			0.9	167	<5	20-25	5-10
		Pad	1.0 x 1.0	243	<5	15-20	5-10
			2.0 x 2.0	247	5-10	35-40	10-15
2.0		Strip	0.4	167	<5	25-30	5-10
			0.9	172	5-10	50-55	15-20
		Pad	1.0 x 1.0	252	5-10	50-55	15-20
			2.0 x 2.0	250	10-15	80-85	25-30
2.5		Strip	0.4	207	5-10	30-35	10-15
			0.9	213	5-10	60-65	15-20
		Pad	1.0 x 1.0	316	5-10	60-65	20-25
			2.0 x 2.0	312	15-20	100-105	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.

The presence of trees within site boundaries indicates that foundations could be within their influence zone. In order to avoid possible excessive settlement due to water removal by trees during dry periods or ground heave due to tree removal, the recommendations of the National House Building Council Practice Standard "Building Near Trees", although not strictly applicable, should be closely followed. In this context clays near surface should be considered as having low volume change potential.

All foundation excavations should be inspected by a suitable qualified engineer to prove that the founding strata is suitable and uniform along the length of the foundation, and capable of taking the anticipated structural loadings. If foundations cross from granular to cohesive soils, nominal reinforcement should be incorporated.

7.4 Pavement Design

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

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 sand.

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 11: 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 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.

7.6 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.

Near surface soft natural clays are unlikely to be suitable as structural fill and should be used for landscaping purposes only, providing they are not contaminated.

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.

7.7 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 in particular 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 general 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 12: 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 (acid)	6 - 7	5 - 6	4 - 5	2 - 4	<2	5.7	B
pH (alkaline)	7 - 8	8 - 9	9 - 10	10 - 12	12	7.3 - 10.1	A - D
Arsenic	0 - 30	30 - 50	50 - 100	100 - 500	500	6 - 62	A - C
Cadmium	0 - 1	1 - 3	3 - 10	10 - 50	50	< 0.2 - 3	A - B
Chromium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	10 - 28	A
Copper	0 - 100	100 - 200	200 - 500	500 - 2500	2500	16 - 190	A - B
Lead	0 - 500	500 - 1000	1000 - 2000	2000 - 1%	1.0%	54 - 491	A
Mercury	0 - 1	1 - 3	3 - 10	10 - 50	50	< 1	A
Nickel	0 - 20	20 - 50	50 - 200	200 - 1000	1000	7 - 76	A - C
Zinc	0 - 250	250 - 500	500 - 1000	1000 - 5000	5000	37 - 521	A - C
Boron	0 - 2	2 - 5	5 - 50	50 - 250	250	< 1 - 1.3	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%	81 - 363	A
Beryllium	0 - 5	5 - 10	10 - 20	20 - 50	50	< 0.5 - 8.4	A - B
Vanadium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	14 - 104	A - B
Sulphate	0 - 2000	2000 - 5000	5000 - 1%	1% - 5%	5.05%	379 - 9389	A - C
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 ranging from uncontaminated to heavily contaminated. A heavy contamination concentration of pH (alkaline) was observed as well as contaminated concentrations of arsenic, nickel, zinc and sulphate. There were also slight contamination concentrations observed of pH (acid), cadmium, copper, beryllium and vanadium. The remaining concentrations are present in uncontaminated concentrations.

Therefore, there is a **LOW to MODERATE** 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/ClEH. 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 13, below.

Table 13: Soil Results Comparison with C4SL/S4UL Values

Parameter	C4SL/S4UL Levels Residential End Use (mg/kg)	WS01 0.40m Made Ground	WS02 0.20m Made Ground	WS03 0.30m Made Ground	WS04 0.25m Made Ground	WS05 0.45m Made Ground	No. of Exceedances
Metals							
Arsenic	37	10	14	23	23	24	0
Boron	290	< 1	< 1	< 1	< 1	< 1	0
Cadmium	22	< 0.2	0.6	0.9	0.7	0.3	0
Chromium III	910	12	12	14	13	15	0
Chromium VI	21	< 2	< 2	< 2	< 2	< 2	0
Copper	2400	16	30	63	102	45	0
Lead	200	54	92	122	180	87	0
Inorganic Mercury	1.2	< 1	< 1	< 1	< 1	< 1	0
Nickel	180	7	14	16	38	39	0
Selenium	250	< 3	< 3	< 3	< 3	< 3	0
Vanadium	410	17	18	25	42	40	0
Zinc	3700	37	243	492	229	91	0
Total Petroleum Hydrocarbons							
Benzene	0.087	< 0.002	< 0.002	< 0.011	< 0.002	< 0.002	0
Toluene	130	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0
Ethylbenzene	47	< 0.002	< 0.002	< 0.011	< 0.002	< 0.002	0
o-xylenes	60	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
m-xylenes	59	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
p-xylenes	56	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
Aliphatic EC >5-6	42	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Aliphatic EC >6-8	100	0.06	0.25	0.08	2.22	< 0.05	0
Aliphatic EC >8-10	27	< 2	< 2	< 2	< 2	< 2	0
Aliphatic EC >10-12	130	< 2	< 2	< 2	< 2	< 2	0
Aliphatic EC >12-16	1100	< 3	< 3	< 3	< 3	< 3	0
Aliphatic EC >16-21	65000	< 3	< 3	< 3	< 3	< 3	0
Aliphatic EC >21-35	65000	< 10	< 10	< 10	38	< 10	0
Aromatic EC >5-7	70	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0
Aromatic EC >7-8	130	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0
Aromatic EC >8-10	34	< 2	< 2	< 2	< 2	< 2	0
Aromatic EC >10-12	74	< 2	< 2	< 2	< 2	< 2	0
Aromatic EC >12-16	140	< 2	< 2	< 2	3	< 2	0
Aromatic EC >16-21	260	< 3	< 3	7	5	< 3	0
Aromatic EC >21-35	1100	< 10	< 10	< 10	27	< 10	0
Polycyclic Aromatic Hydrocarbons							
Naphthalene	2.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Acenaphthylene	210	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Acenaphthene	170	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Fluorene	170	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Phenanthrene	95	< 0.1	< 0.1	0.98	0.37	0.16	0
Anthracene	2400	< 0.1	< 0.1	0.27	< 0.1	< 0.1	0
Fluoranthene	280	< 0.1	< 0.1	1.08	0.71	0.31	0
Pyrene	620	< 0.1	< 0.1	1	0.68	0.27	0
Benzo(a)anthracene	7.2	< 0.1	< 0.1	0.51	0.34	< 0.1	0
Chrysene	15	< 0.1	< 0.1	0.61	0.41	0.14	0
Benzo(a)pyrene	5	< 0.1	< 0.1	0.49	0.28	< 0.1	0
Benzo(b)fluoranthene	2.6	< 0.1	< 0.1	0.58	0.47	0.11	0
Benzo(k)fluoranthene	77	< 0.1	< 0.1	0.22	0.16	< 0.1	0
Indeno(1,2,3-cd)pyrene	27	< 0.1	< 0.1	0.33	0.19	< 0.1	0

Parameter	C4SL/S4UL Levels Residential End Use (mg/kg)	WS01 0.40m Made Ground	WS02 0.20m Made Ground	WS03 0.30m Made Ground	WS04 0.25m Made Ground	WS05 0.45m Made Ground	No. of Exceedances
Dibenz(a,h)anthracene	0.24	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Benzo(ghi)perylene	320	< 0.1	< 0.1	0.29	0.15	< 0.1	0
Phenols							
Phenol	280	< 2	< 2	< 2	< 2	< 2	0
Volatile Organic Compounds							
Cis 1,2 Dichloroethene					0.083	< 0.005	0
Tetrachloroethene (PCE)	0.18				7.334	0.136	1
Trichloroethene (TCE)	0.016				2.141	< 0.005	1
Vinyl Chloride	0.00064				< 0.005	< 0.005	0

Concentrations in red are above the assessment criteria based on Residential End Use with Plant Uptake.

Parameter	C4SL/S4UL Levels Residential End Use (mg/kg)	WS05 1.20m Made Ground	WS06 0.50m Made Ground	WS07 0.80m Made Ground	WS08 0.60m Made Ground	No. of Exceedances
Metals						
Arsenic	37	31	15	6	62	1
Boron	290	< 1	1.3	< 1	< 1	0
Cadmium	22	0.2	< 0.2	0.5	3	0
Chromium III	910	21	19	10	28	0
Chromium VI	21	< 2	< 2	< 2	< 2	0
Copper	2400	42	134	22	190	0
Lead	200	476	56	104	491	2
Inorganic Mercury	1.2	< 1	< 1	< 1	< 1	0
Nickel	180	17	59	10	76	0
Selenium	250	< 3	< 3	< 3	< 3	0
Vanadium	410	29	68	14	104	0
Zinc	3700	136	76	68	521	0
Total Petroleum Hydrocarbons						
Benzene	0.087	< 0.002	< 0.002	< 0.002	< 0.002	0
Toluene	130	< 0.005	< 0.005	< 0.005	< 0.005	0
Ethylbenzene	47	< 0.002	< 0.002	< 0.002	< 0.002	0
o-xylenes	60	< 0.002	< 0.002	< 0.002	< 0.002	0
m-xylenes	59	< 0.002	< 0.002	< 0.002	< 0.002	0
p-xylenes	56	< 0.002	< 0.002	< 0.002	< 0.002	0
Aliphatic EC >5-6	42	< 0.01	< 0.01	< 0.01	< 0.01	0
Aliphatic EC >6-8	100	< 0.05	< 0.05	< 0.05	0.07	0
Aliphatic EC >8-10	27	< 2	< 2	< 2	2	0
Aliphatic EC >10-12	130	< 2	< 2	< 2	23	0
Aliphatic EC >12-16	1100	< 3	< 3	< 3	116	0
Aliphatic EC >16-21	65000	< 3	< 3	< 3	196	0
Aliphatic EC >21-35	65000	< 10	< 10	< 10	238	0
Aromatic EC >5-7	70	< 0.01	< 0.01	< 0.01	< 0.01	0
Aromatic EC >7-8	130	< 0.05	< 0.05	< 0.05	< 0.05	0
Aromatic EC >8-10	34	< 2	< 2	< 2	< 2	0
Aromatic EC >10-12	74	< 2	< 2	< 2	4	0
Aromatic EC >12-16	140	< 2	< 2	< 2	34	0
Aromatic EC >16-21	260	< 3	4	< 3	92	0
Aromatic EC >21-35	1100	< 10	< 10	< 10	201	0
Polycyclic Aromatic Hydrocarbons						
Naphthalene	2.3	< 0.1	< 0.1	< 0.1	0.17	0
Acenaphthylene	210	< 0.1	< 0.1	< 0.1	< 0.1	0
Acenaphthene	170	< 0.1	< 0.1	< 0.1	< 0.1	0
Fluorene	170	< 0.1	< 0.1	< 0.1	< 0.1	0
Phenanthrene	95	0.16	0.32	< 0.1	0.17	0
Anthracene	2400	< 0.1	< 0.1	< 0.1	< 0.1	0
Fluoranthene	280	0.31	0.39	< 0.1	0.16	0
Pyrene	620	0.31	0.30	< 0.1	0.20	0
Benzo(a)anthracene	7.2	< 0.1	0.14	< 0.1	< 0.1	0

Parameter	C4SL/S4UL Levels Residential End Use (mg/kg)	WS05 1.20m Made Ground	WS06 0.50m Made Ground	WS07 0.80m Made Ground	WS08 0.60m Made Ground	No. of Exceedances
Chrysene	15	0.15	0.14	< 0.1	0.13	0
Benzo(a)pyrene	5	< 0.1	< 0.1	< 0.1	< 0.1	0
Benzo(b)fluoranthene	2.6	0.14	0.14	< 0.1	0.13	0
Benzo(k)fluoranthene	77	< 0.1	< 0.1	< 0.1	< 0.1	0
Indeno(1,2,3-cd)pyrene	27	< 0.1	< 0.1	< 0.1	< 0.1	0
Dibenz(a,h)anthracene	0.24	< 0.1	< 0.1	< 0.1	< 0.1	0
Benzo(ghi)perylene	320	< 0.1	< 0.1	< 0.1	< 0.1	0
Phenols						
Phenol	280	< 2	< 2	< 2	< 2	0
Volatile Organic Compounds						
Cis 1,2 Dichloroethene	0.0071		< 0.005	< 0.005	< 0.005	0
Tetrachloroethene (PCE)	0.18		0.206	0.075	1.54	2
Trichloroethene (TCE)	0.016		0.007	< 0.005	0.061	1
Vinyl Chloride	0.00064		< 0.005	< 0.005	< 0.005	0

Concentrations in red are above the assessment criteria based on Residential End Use with Plant Uptake.

Potential contaminants of concern have been found in exceedance of long term human health screening criteria for a residential end use (with plant uptake in gardens).

The exceedances include:

Arsenic WS08 0.60m

Lead WS05 1.20m, WS08 0.60m

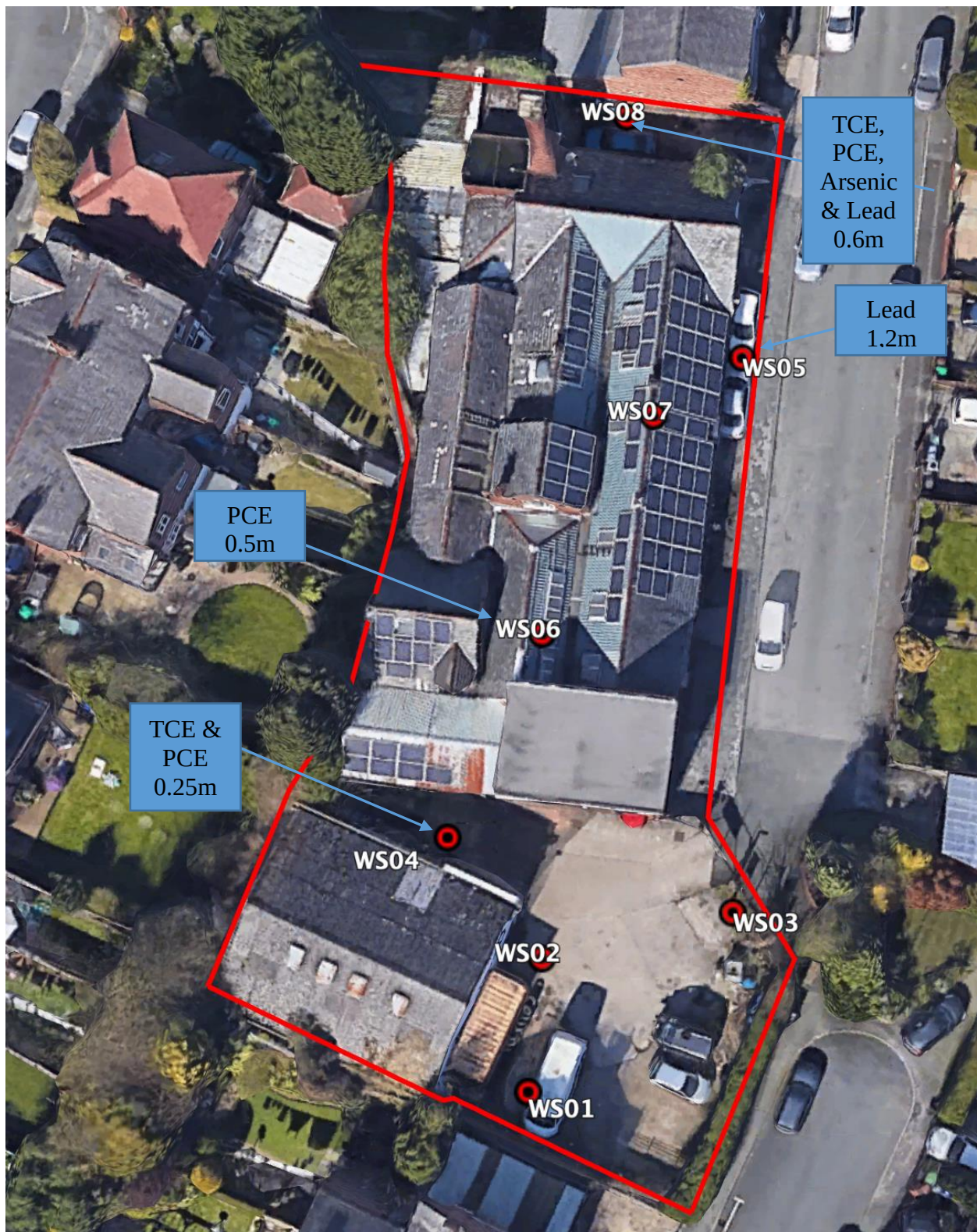
Tetrachloroethene (PCE) WS04 0.25m, WS06 0.50m, WS08 0.60m

Trichloroethene (TCE) WS04 0.25m, WS08 0.60m

The locations of these exceedances can be observed in Figure 9 below.

Asbestos fibres and fragments have not been identified any of the samples collected.

Figure 9: Soil Chemical Exceedance Location Plan



Location	Depth (m bgl)	WM3.1 Classification
WS07	0.80	Non-Hazardous
WS08	0.60	Non-Hazardous

Table 15, above shows that the nine soil samples collected from the windowless sampling boreholes are classified as **Non-Hazardous** in accordance with WM3.1.

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

9.0 CONTROLLED WATER RISK ASSESSMENT

In the absence of specific UK guidelines regarding groundwater quality in the UK, chemical results obtained by EEG have been compared with the following statutory and non-statutory standards:

- Environmental Quality Standards (EQS); and
- UK Drinking Water standards⁽²⁰⁰⁰⁾.

The existing Groundsure report indicates there is one active and two historical groundwater abstraction licences within 2km of the study site. The active license is located at Didsbury Golf Club, Northenden 1.1km north east of site, used for spray irrigation.

The two historical licenses are located 1.2km south east and 1.9km south east used for laundry use and spray irrigation.

The Groundsure report indicates there is one historical surface water abstraction license within 2km of the study site, located 1km north of site from the River Mersey for dust suppression and general/ process washing.

The site is not located within 500m of a groundwater source protection zone.

The nearest controlled water is Gatley Brook 1.1km to the south east of the site.

Shallow groundwater has been found at all monitoring with depth range of 1.45m to 2.02m. The shallow table is supported within a sand horizon in WS01, WS02, WS03, WS04, WS07, WS08 and a horizon of clay at WS05, WS06.

The environmental setting of the site with respect to controlled waters is therefore one of a low risk due to an absence of controlled waters and local abstraction points.

As a result the concentration of potential contaminants of concern in water samples recovered from monitoring wells have been compared to Environmental Quality Standards (EQS) and UK Drinking Water Standards.

The results are summarised in Table 16 overleaf.

Chlorinated solvents (including PCE & TCE) have been found in shallow water samples recovered from the monitoring wells. The concentrations have been compared to conservative drinking water and environmental quality standards.

Exceedances have been found at:

Tetrachloroethene (PCE) WS01, WS04, WS05, WS06, WS08

Trichloroethene (TCE) WS01, WS04, WS06

The maximum recorded PCE concentration was found at WS04 (16890µg/litre).

The maximum recorded TCE concentration was found at WS06 (1319µg/litre).

It should be noted that the most toxic form of chlorinated solvent, vinyl chloride, has not been found.

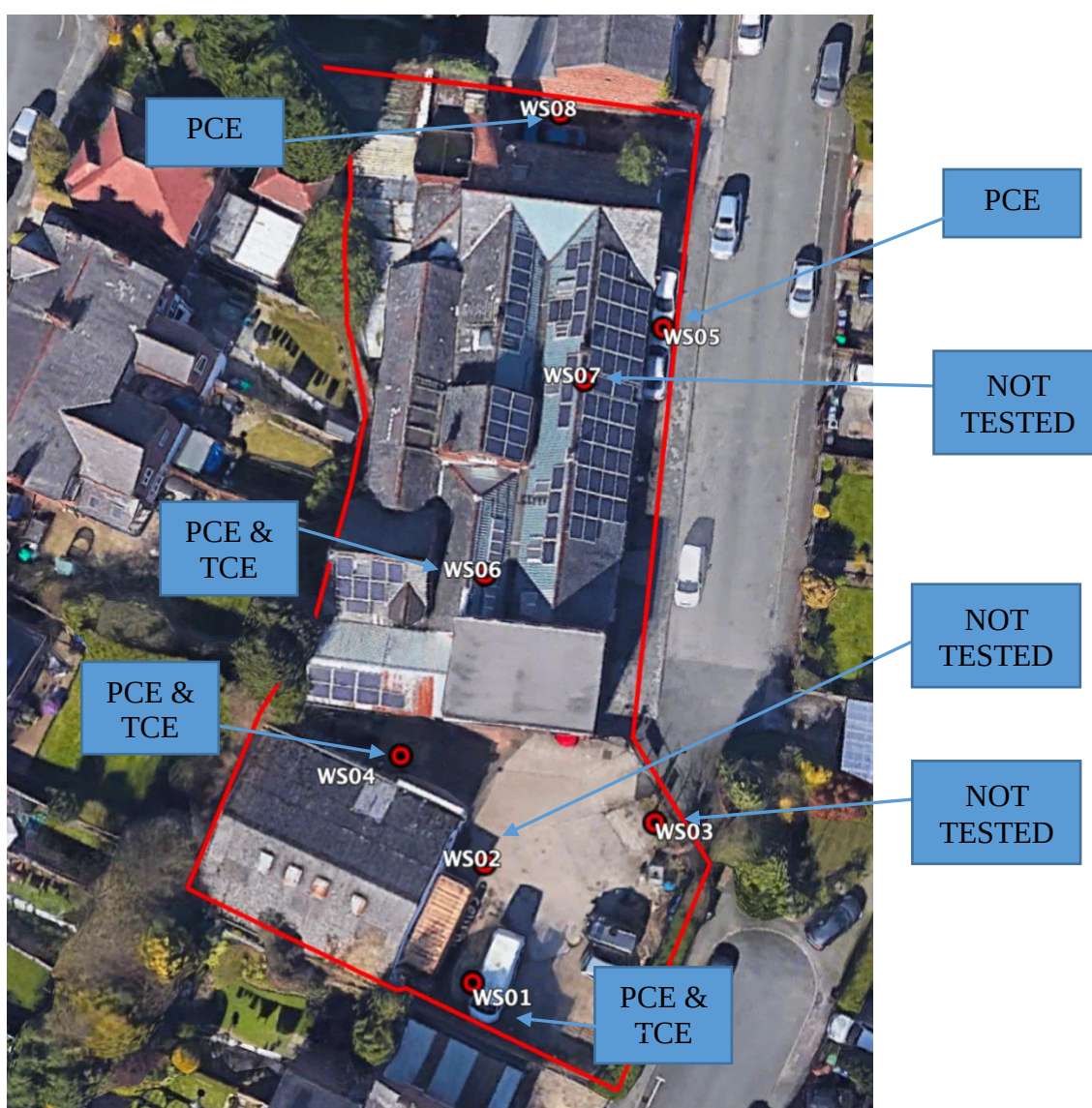
Figure 9 provides a summary of the exceedances and shows site wide exceedances of solvents within the shallow groundwater system.

Table 16: Groundwater Results Comparisons with EQS/Drinking Water Quality Values (µg/l)

Determinand	EQS Value (1) µg/l	Drinking Water Quality (DWQ) Value (2) µg/l	WS01 2.0m	WS04 1.50m	WS05 1.54m	WS06 1.62m	WS08 1.45m	No. of Exceedances
Arsenic	50	10	< 5	< 5	9	< 5	< 5	0
Cadmium		5	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	0
Chromium	50	-	< 5	< 5	< 5	< 5	< 5	0
Copper		2000	< 5	< 5	9	< 5	< 5	0
Lead		10	< 5	< 5	< 5	< 5	< 5	0
Mercury	0.07	1.0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0
Selenium	-	10	< 5	< 5	< 5	< 5	< 5	0
Nickel	50 - 200	20	< 5	< 5	11	< 5	< 5	0
Zinc		5000	10	13	14	10	8	0
Cyanide	-	50	< 5	< 5	< 5	< 5	< 5	0
Phenol		500	< 10	< 10	490	16	< 10	0
Sulphate		250000	35	62	34	121	47	0
pH		-	6.6	6.6	8.0	7.4	7.5	0
Naphthalene	2.0	-	0.09	0.02	0.02	0.03	< 0.01	0
Anthracene	0.1	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Benzo(a)pyrene		0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Benzo(b)fluoranthene		0.10	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Benzo(k)fluoranthene		0.10	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Indeno(123cd)pyrene	-	0.10	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Fluoranthene		-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Benzene		< 1	< 1	< 1	< 1	< 1	< 1	0
Toluene		700	< 5	< 5	< 5	< 5	< 5	0
Ethylbenzene		300	< 5	< 5	< 5	< 5	< 5	0
Xylenes		500	< 15	< 15	< 15	< 15	< 15	0
Total Petroleum Hydrocarbons Aro C5-C6		10	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C6-C8	-	700	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C8-C10	-	300	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C10-C12	-	90	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C12-C16	-	90	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C16-C21	-	90	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C21-C35	-	90	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Ali C5-C6		15000	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Ali C6-C8	-	15000	172	1505	10	1926	< 10	0
Total Petroleum Hydrocarbons Ali C8-C10	-	15000	< 10	< 10	< 10	< 10	< 10	0

Determinand	EQS Value (1) µg/l	Drinking Water Quality (DWQ) Value (2) µg/l	WS01 2.0m	WS04 1.50m	WS05 1.54m	WS06 1.62m	WS08 1.45m	No. of Exceedances
Total Petroleum Hydrocarbons Ali C10-C12	-	300	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Ali C12-C16	-	300	< 10	< 10	< 10	< 10	< 10	0
Cis 1,2 Dichloroethene			19	1053	<5	595	<5	0
Tetrachloroethene (PCE)	10	10	1092	16890	40	13820	18	5
Trichloroethene (TCE)	10	10	153	452	10	1319	<5	3
Vinyl Chloride		0.5	<5	<5	<5	<5	<5	0

Figure 9: Water Chemical Exceedance Location Plan



9.1 Vapour Risk from Groundwater

The risk to human health for a residential end use scenario has been assessed by reference to Society of Brownfield Risk Assessment (SOBRA) Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater, February 2017.

Table 17: Vapour Risk from Volatile Compounds (µg/l)

Determinand	SOBRA GAC	Aqueous Solubility µg/l	WS01 2.0m	WS04 1.50m	WS05 1.54m	WS06 1.62m	WS08 1.45m	No. of Exceedances
Naphthalene	220	19,000	0.09	0.02	0.02	0.03	< 0.01	0
Acenaphthene	170,000	4,100	<0.01	<0.01	<0.01	<0.01	<0.01	0
Acenaphthylene	220,000	7,950	<0.01	<0.01	<0.01	<0.01	<0.01	0
Fluorene	210,000	1,860	<0.01	<0.01	<0.01	<0.01	<0.01	0
Benzene	210	1,780,000	< 1	< 1	< 1	< 1	< 1	0
Toluene	230,000	590,000	< 5	< 5	< 5	< 5	< 5	0
Ethylbenzene	10,000	180,000	< 5	< 5	< 5	< 5	< 5	0
Xylenes	9,500	200,000	< 15	< 15	< 15	< 15	< 15	0
Total Petroleum Hydrocarbons Aro C5-C6	210,000	1,780,000	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C6-C8	220,000	590,000	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C8-C10	1,900	64,600	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C10-C12	6,800	24,500	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C12-C16	39,000	5,750	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C16-C21			< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C21-C35			< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Ali C5-C6	1,900	35,900	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Ali C6-C8	1,500	5,370	172	1505	10	1926	< 10	2
Total Petroleum Hydrocarbons Ali C8-C10	57	427	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Ali C10-C12	37	34	< 10	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Ali C12-C16			< 10	< 10	< 10	< 10	< 10	0
Cis 1,2 Dichloroethene	130	7,550,000	19	1053	<5	595	<5	0
Tetrachloroethene (PCE)	34	225,000	1092	16890	40	13820	18	5
Trichloroethene (TCE)	5.7	1,370,000	153	452	10	1319	<5	3
Vinyl Chloride	0.62	2,760,000	<5	<5	<5	<5	<5	0

The SOBRA groundwater vapour GAC (GAC_{gwvap}) are intended as a conservative screening tool that assessors may choose to use to help assess the long-term (chronic) risks to human health from inhalation of vapours arising from groundwater. They are intended for comparison with measured groundwater concentrations and represent the estimated concentration in groundwater below which the long-term risks to human health from vapour migration and inhalation can be considered low/tolerable, i.e. unlikely to be of concern (for the land use scenarios considered). When used as part of a Generic Quantitative Risk Assessment (GQRA) (which includes consideration of uncertainties – see Defra and Environment Agency, 2004) comparison of the GAC_{gwvap} with measured concentrations in groundwater can be used to screen out contaminants as being unlikely to represent an unacceptable risk to humans living or working above the groundwater plume.

The GAC_{gwvap} have been developed in line with UK risk assessment guidance (e.g. Defra and Environment Agency, 2004; Environment Agency, 2009a) and are intended to be used for sites in the UK.

The GAC have been derived for two land use scenarios for which the vapour intrusion pathway is likely to require assessment: residential and commercial.

Generic assumptions have been made for each land use. These include assumptions about the depth to groundwater (default depth of 0.65m), soil type in the unsaturated zone (default of sand), building dimension (default small terraced house) and foundation type, and receptor behaviour.

As described in CLEA SR3 report (Environment Agency, 2009a) the parameter values have been chosen to ensure that the GAC are precautionary for the vast majority of commercial and residential properties in the UK.

A risk to human health from volatile compounds in shallow groundwater have been found at WS01, WS04, WS05 and WS06.

Solubility limits have not been exceeded at any location.

10.0 GROUND GAS AND RADON GAS CONTAMINATION RISK ASSESSMENT

10.1 Radon Gas

The site is not located within a Radon Affected Area as defined by the Health Protection Agency, as less than 1% of properties are above the Action Level of exposure. Therefore, radon protection measures are not necessary.

10.2 Bulk Ground Gases (Methane, Carbon Dioxide and Oxygen)

The potential risk associated with gases being generated in the ground (whether from natural or man-made sources) depends on the concentrations of gas and its flow rate to the surface. These factors are assessed by monitoring of the gas installations in the boreholes. The variable nature of gas generation and the effect of barometric pressure on gas flow, means that the volume of gas potentially reaching the ground surface is normally inconsistent over time.

Four gas monitoring visits have been completed by Earth Environmental & Geotechnical Ltd. The monitoring visits were conducted on the 9th, 15th, 22nd and 29th April 2021. The results recorded methane (CH₄) levels of 0.0% (v/v) and carbon dioxide (CO₂) levels of 0.1% to 6.3% v/v. Oxygen concentrations of between 14.1% to 20.6% v/v were also recorded.

Gas flow rates ranged from -0.1l/hr to 0.0l/hr and a maximum flow rate of 0.1l/hr (detection limit of instrument) has been adopted for the calculations below. Atmospheric pressure was recorded to be 1009 and 1031mb. PID testing was also conducted and revealed an absence of volatile organic compounds in the headspace of monitoring wells.

Full results of the monitoring visits are presented in Appendix 4.

Table 17 overleaf, adapted from Table 1 of the technical paper Risk and Reliability in Gas Protection Design by Card et al. 2019, shows a summary of the current UK practice with respect to appropriate gas protection measures based upon a Gas Screening Value (GSV).

A GSV for the site has been obtained by multiplying the maximum concentration of gas by the maximum flow rate, which represents worst-case scenario conditions.

- Carbon dioxide: maximum flow rate = 0.1l/hr, max concentration = 6.3%
- Methane: maximum flow rate = 0.1l/hr, max concentration = 0.0%.

Based on the above figures, the GSV is calculated as:

- **Carbon dioxide:** $GSV = 0.1 \times 6.3 / 100 = 0.0063 \text{ litres/hr}$
- **Methane:** $GSV = 0.1 \times 0.0 / 100 = 0.0000 \text{ litres/hr}$

The above results suggest the site can be given a Gas Regime A classification, i.e. '**NEGLIGIBLE to VERY LOW risk**', in accordance with Table 18, overleaf.

Table 18: Modified Ground Gas Classification Table (Risk and Reliability in Gas Protection Design, 2019)

<i>Characteristic Situation</i>	<i>Pathway vertical permeability (m/s)</i>	<i>GSV CH₄ (l/hr)</i>	<i>GSV CO₂ (l/h)</i>	<i>GSV oxygen deficient gas (Nitrogen) (l/h)</i>	<i>Maximum borehole gauge pressure (Pa)</i>	<i>Limiting sustained gas concentrations in unsaturated zone within 10m of surface</i>	<i>Limitations</i>	<i>Risk level</i>
Gas Regime A	$\leq 1 \times 10^{-7}$ $1 \times 10^{-7} < k < 1 \times 10^{-5}$ $\geq 1 \times 10^{-5}$	< 2 < 1.5 < 1.3	< 12 < 9 < 7	< 217 for all permeability (care when using this value. Usually oxygen deficient gas emissions are sporadic, and monitoring should cover suitable conditions)	500 (50mm water) – ASTM (2016)	$< 30\%$ methane $< 21\%$ carbon dioxide Not applicable where municipal solid waste landfills, mine workings or similar credible sources with credible pathways for migration are present. Not applicable where potential ground gas reservoirs are connected to buildings.	No limit on oxygen depletion because it is widespread in natural soils and fill materials due chemical and biological processes Consider whether pressurisation could realistically occur and over what timescales where potential ground gas reservoirs are connected to buildings.	Negligible to very low
Gas Regime B	$\leq 1 \times 10^{-7}$ $1 \times 10^{-7} < k < 1 \times 10^{-5}$ $\geq 1 \times 10^{-5}$	≤ 10 ≤ 7.5 ≤ 6	< 140 < 100 < 85	No Limit	No limit	-		Low to moderate
Gas Regime C	$\leq 1 \times 10^{-7}$ $1 \times 10^{-7} < k < 1 \times 10^{-5}$ $\geq 1 \times 10^{-5}$	≤ 100 ≤ 75 ≤ 60	No limiting values	No Limit	No limit	No limit	Where oxygen deficient ground gas or carbon dioxide is likely to be emitted from shafts, fractured rock or ground where $k > 1 \times 10^{-4}$ m/s undertake DQRA	Moderate to high

Gas Regime D	-	N/A	N/A	N/A	-	-	DQRA required	Very high
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11.0 CONCLUSIONS & RECOMMENDATIONS

11.1 Local Geology

The site investigation has proved a thin mantle of Made Ground underlain by a sand horizon and at two locations (WS05 & WS06) underlain by clay.

11.2 Hydrology and Hydrogeology

The site is not located within 1km of a surface water or a surface/groundwater abstraction borehole.

The sand and gravel that underlies the site is classified by the Environment Agency as a Secondary A aquifer.

11.3 Soil Contamination

There is a low to moderate 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.

Several exceedances of long term human health assessment criteria have been found detected in shallow soils including metals and chlorinated solvents.

Chlorinated solvents have been found in shallow soil and these pose an inhalation risk to future occupiers of residential properties. As a result remedial measures will be required which could take the form of in-situ soil treatment or by the introduction of a vapour barrier in the foundations.

A cover system will need to be placed within garden areas which would break pollutant linkages. Given the shallow water table and the presence of chlorinated solvents it would be prudent to install a capillary break layer as part of the cover system.

Any remedial works will need to be described within a Remediation Strategy.

11.4 Water Contamination

A shallow water table has been identified on the site that is largely supported by a sand horizon.

Several exceedances of long-term human health assessment criteria have been found detected in water samples recovered from monitoring wells.

Given the environmental setting of the site the risk to controlled waters (rivers, ponds, streams, canals) is low.

Chlorinated solvents have been found in water samples and these pose an inhalation risk to future occupiers of residential properties. As a result remedial measures will be required which could take the form of in-situ soil treatment or by the introduction of a vapour barrier in the foundations.

Any remedial works will need to be described within a Remediation Strategy.

11.5 Post Demolition Site Investigation

Following the demolition of the structures a further soil sampling exercise should be conducted in order to further characterise the lateral and vertical distribution of chlorinated solvents.

11.6 Foundations

Shallow strip/pad foundation placed in the superficial deposits at a minimum depth of approximately 0.9m bgl are considered appropriate for the proposed development localised deepened trench footings used in areas of deep made ground.

11.7 Asbestos

Asbestos fibres and fragments have not been found at any location.

11.8 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 for the purpose of off-site disposal in accordance with Environment Agency guidance WM3.1.

11.9 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).

11.10 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.

11.11 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

GEOTECHNICAL TESTING RESULTS

APPENDIX 3

CHEMICAL TESTING RESULTS

APPENDIX 4

ENVIRONMENTAL MONITORING DATA

APPENDIX 5

SOIL WASTE ASSESSMENT

APPENDIX 6

REPORT LIMITATIONS

REPORT LIMITATIONS

This contract was completed by Earth Environmental & Geotechnical Ltd on the basis of 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 in light of 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 from 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.