



**EARTH ENVIRONMENTAL
& GEOTECHNICAL**
A Technics Group Company



Phase II GeoEnvironmental Ground Investigation

54 Derby Street, Cheetham Hill

Manchester

January 2026

On behalf of

Kacoo Investments Ltd



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PHASE 2 GEOENVIRONMENTAL

SITE INVESTIGATION REPORT

54 DERBY STREET, CHEETHAM HILL

MANCHESTER

FOR

KACOO INVESTMENTS LTD

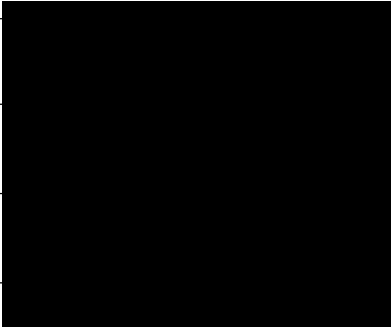
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1.0 INTRODUCTION

1.1 Background

A site investigation has been commissioned by Lapas Chowdhury, on behalf of Kacoo Investments Ltd (the Client) to examine ground conditions for a proposed new development at 54 Derby Street, Cheetham Hill, Manchester.

1.2 Existing Planning Applications

1.2.1 Planning Application to Manchester City Council, Ref - 141689/FO/2024, dated December 2024.

A planning application has been submitted for the site to Manchester City Council (Reference: 141689/FO/2024) for the construction of a single storey building comprising 2no. units (B8 storage or distribution) with associated alterations to car parking layout.

The application was approved in February 2025.

1.3 Terms of Reference

The Client has commissioned Earth Environmental and Geotechnical Ltd (EEG) to undertake a site investigation in accordance with proposal A6542/25/V1 dated 23rd September 2025. The objectives of this investigation are as follows:

- *Provide factual information on the work undertaken, including sampling location plan, borehole logs, and geotechnical and chemical testing.*
- *Tier 1 (semi-quantitative) risk assessment will be undertaken. This will compare the concentrations of soil, groundwater & 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 soils for off-site disposal.*
- *Assessment of ground conditions for foundation design.*

1.4 Report Scope

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

1.5 Limitations of the Study

The report is written within the 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 reserves the right to amend either conclusions or recommendations in light of any further information that may become available. The report is provided solely for the client's use 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 the accuracy of the data supplied, all opinions expressed regarding the spatial distribution of strata between sampling locations are for guidance only, and no responsibility is accepted for their accuracy.

1.6 Previous Investigations

1.6.1 *Earth Environmental & Geotechnical Ltd, Phase 1 GeoEnvironmental Desk Study, 54 Derby Street, Cheetham Hill, Ref: A6542/25/FDS/V2, dated March 2025*

Earth Environmental & Geotechnical Ltd have conducted a previous Phase 1 GeoEnvironmental Desk Study for the site. The report highlighted the following:

Historical mapping dated 1848 recorded the site and surrounding area to initially comprise undeveloped land, with a pond in the east of the site, and residential development to the west of the site. In the 1890s the east of the site was occupied by a clay pit, which extended to the northeast of the site, assumed to be associated with a brick works approximately 100m north of the site. At this stage a large building was constructed in the south of the site which was recorded as a police station in 1906. By 1908, the clay pit on site was infilled and was recorded as undeveloped until 1933 where Aquatite Mill was recorded to occupy the majority of the site. At this stage, the structure which was recorded as a police station was spilt into multiple buildings, potentially used for residential use. Other than the mill being divided into an electrical engineering works and the original mill in the 1950s, the site underwent little change until the 1970s where the whole building was recorded as a printing works. By the late 1980s, the site was in its modern day configuration.

The area surrounding the site was originally unoccupied with small residential developments to the west. Brick works and other industrial/ commercial works later occupied the area, particularly from the 1900s. By the 1960s, the clay pits to the north of the site were infilled, with further works, warehouses and offices constructed.

The superficial deposits beneath the site are recorded as Devensian Till, comprising clay and sand with or without boulders. The bedrock geology beneath the site is recorded as the Chester Formation, comprising sandstone. It was noted that due to the historical setting of the site, made ground was anticipated.

The overall risk from soil contamination to receptors was concluded to be **MODERATE to LOW**.

The overall risk to controlled waters was concluded to be **LOW** based on the limited source potential and the lack of nearby surface water features.

Although possible ground gas sources were identified onsite and within 250m of the site, due to the age of infilled material, the risk from ground gas to end users was considered to be **MODERATE to LOW**.

The site is not located in a radon-affected area, Therefore it was concluded that no radon protection measures are required in any new structures.

The Phase 1 Geoenvironmental Desk Study recommends that a further intrusive investigation be undertaken to establish geotechnical parameters for the design of foundations, as well as to recover soil samples for contamination testing. It was additionally recommended that ground gas monitoring should be undertaken as part of any further investigation.

2.0 SITE LOCATION & DESCRIPTION

The site (1.04 hectares) is located within a commercial setting in Cheetham Hill. The approximate National Grid Reference for the centre of the site is SJ 83918 99930 (X: 383918, Y: 399930)) with the nearest postcode being M4 6DH.

The site is a generally square shaped parcel of land with maximum dimensions of approximately 141m northwest to southeast and 150m northeast to southwest.

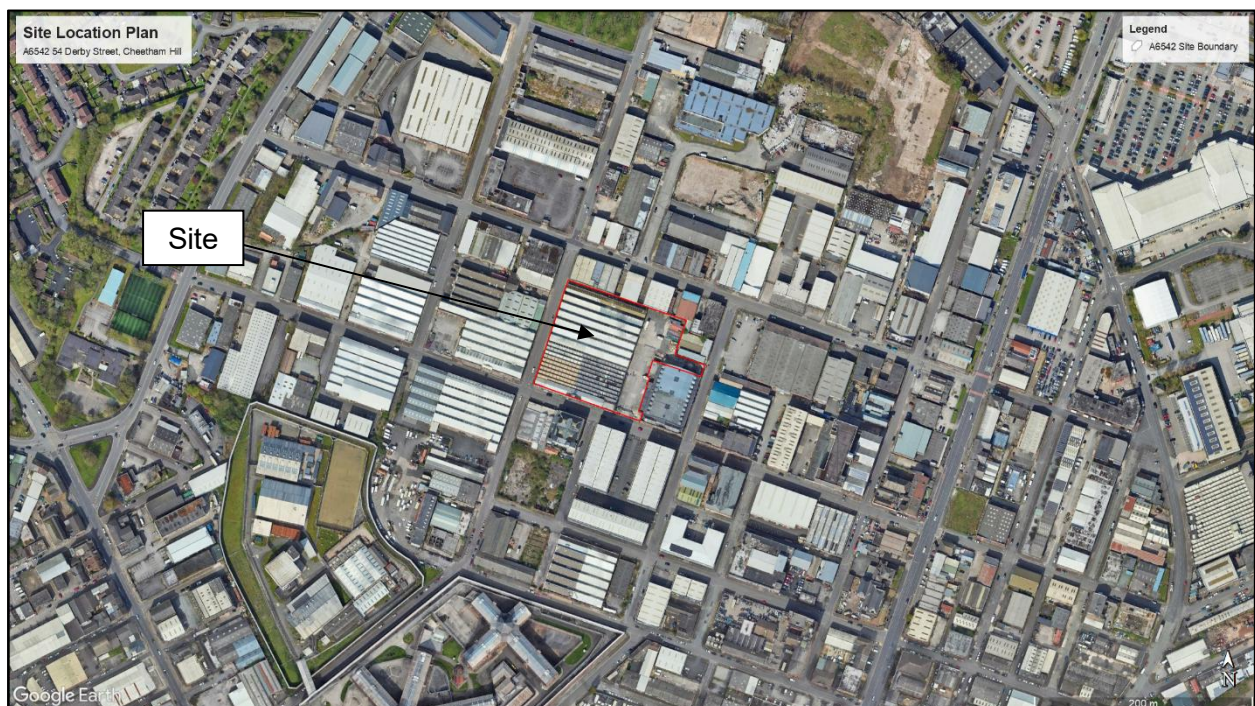
The site is currently occupied by a commercial warehouse, which is segregated in to multiple commercial businesses. The remainder of the site, including the proposed development area in the northeast of the site, comprises hardstanding associated with access and parking for the surrounding commercial units

Access to the site can be gained via a metal fence gate, to the south of the site off Derby Street.

The site is surrounded by commercial properties, with Manchester Prison (aka Stangeways Prison) located approximately 190m south of the site. It is understood that the closest residential properties to the site are located approximately 360m west of the site.

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

Figure 1: Site Location Plan



General site photographs are presented in Figure 2 overleaf.

Figure 2: General Site Photographs

Photograph facing north, showing overview of existing site layout



Photograph showing natural strata, exclusively observed in WS01

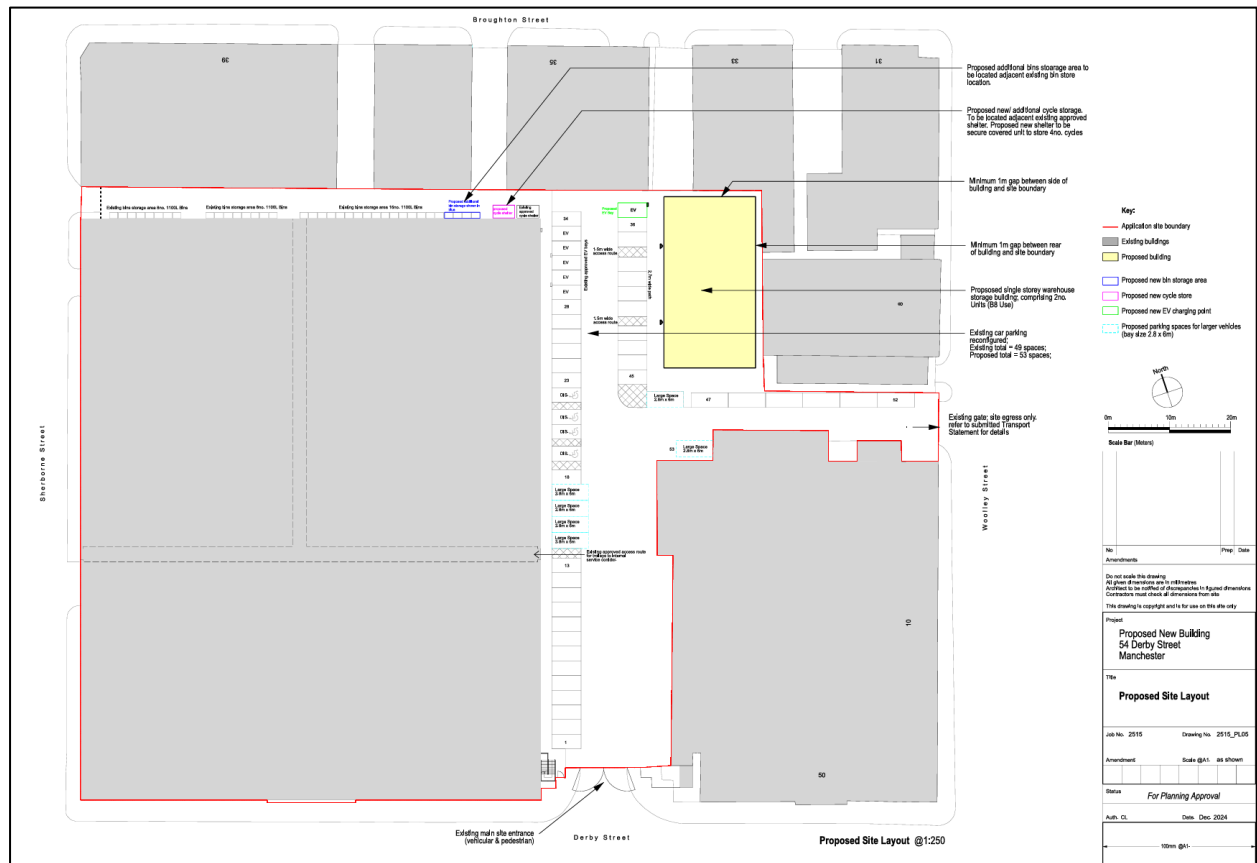


2.1 Proposed Development

It is understood the client is proposing to construct a new single storey commercial building, comprising 2no. units, along with associated alterations to the car parking layout.

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

Figure 3: Proposed Development Plan



3.0 SITE INVESTIGATION

3.1 Exploratory Fieldwork

The fieldwork was carried out by EEG on the 3rd December 2025 and comprised:

- 4no. window sample boreholes (designated WS01 - WS04 inclusive) were sunk to depths between 3.70m and 6.00m below the existing ground level. The boreholes were all drilled with the intention of reaching 6.00m bgl; however, one location was terminated early due to SPT refusals in very stiff clay. Standard Penetration Tests (SPTs) were undertaken in the borehole in accordance with BS EN ISO 22476-3. Groundwater observations were noted where possible. These observations pertain only to the time of the investigation and do not necessarily reflect seasonal fluctuations. Exploratory hole logs are included in Appendix 1.

Exploratory hole locations were selected by EEG Ltd prior to the site works, based on the proposed development, and to avoid known services.

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

Table 1 below outlines the targeted features.

Table 1: Sampling Location Justification

Exploratory Hole	Sampling Location
WS01 - WS04	Within the footprint of the proposed development.

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

Soil samples were recovered in 250g glass amber jars and 1kg plastic tubs. 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 the 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 an EEG representative. 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 using a handheld Trimble GeoXH GPS instrument capable of surveying to an accuracy of less than 10mm, depending on satellite coverage, proximity to trees, and building structures.

The descriptive terminology, such as firm, etc., formerly used in older versions of BS5930 to describe strength, now relates solely to consistency. Shear strength is now defined in relation to

results obtained in the field (using a hand vane, for example) or in the laboratory (from triaxial tests), as detailed in Table 2 below.

Table 2: 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	150 to 300
Extremely High Strength	300 to 600

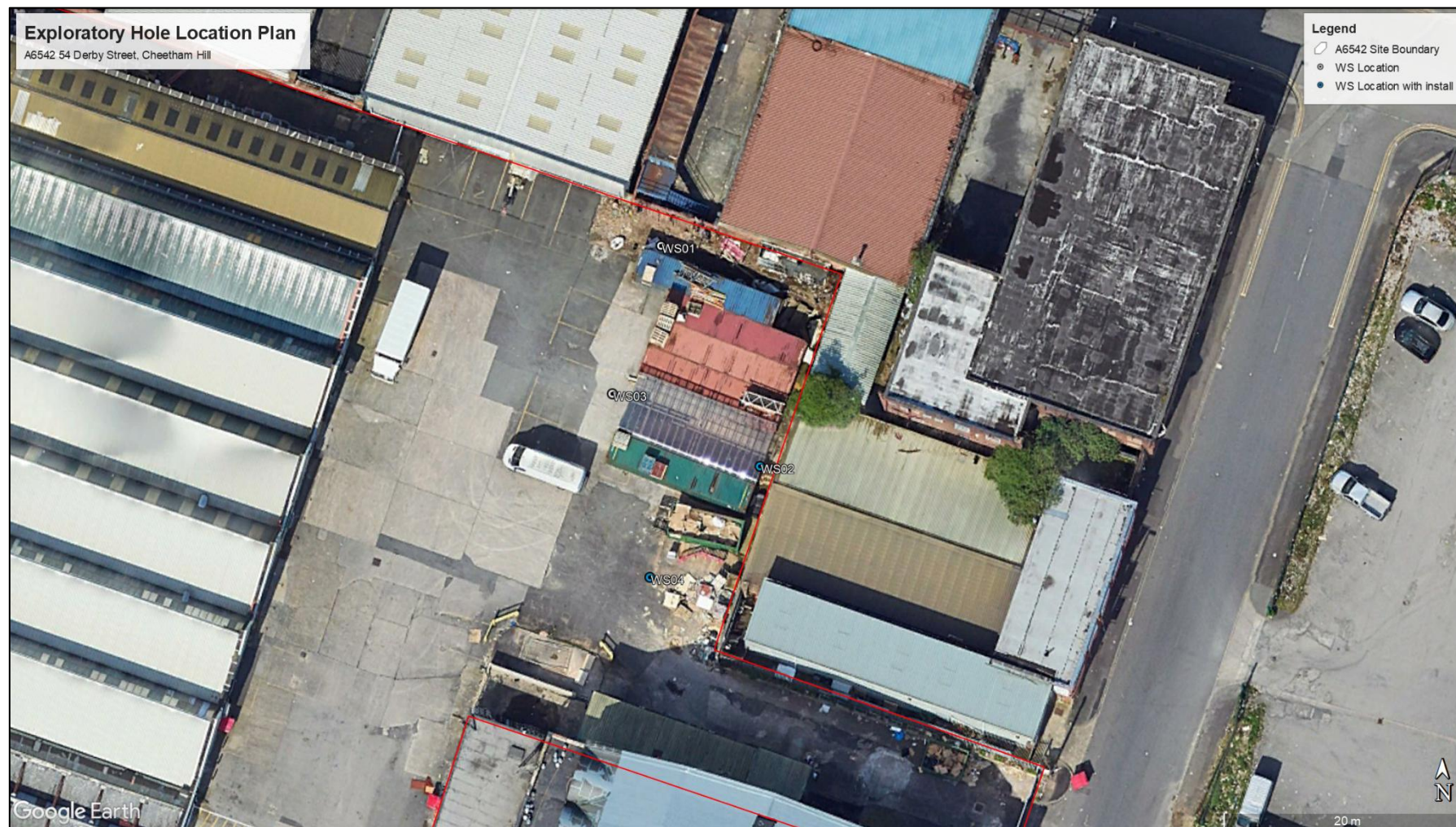
An Exploratory Hole Location Plan is presented as Figure 4, overleaf.

A summary of exploratory holes and tests undertaken during the investigation is presented in Table 3 below.

Table 3: Summary of Exploratory Holes Undertaken

Hole/ Test	Type*	Depth (m)	Date Started	Date Finished	Easting (m)	Northing (m)	Backfill Details**
WS01	WS	3.70	03/12/2025	03/12/2025	399952	383992	A
WS02	WS	6.00	03/12/2025	03/12/2025	399934	384003	M
WS03	WS	6.00	03/12/2025	03/12/2025	399940	383991	A
WS04	WS	6.00	03/12/2025	03/12/2025	399925	383994	M
*WS = Window Sample Borehole, CP = Cable Percussion Drilling, TP = Trial Pit							
**M = Monitoring Well, B = Bentonite, A = Arisings							

Figure 4: Exploratory Hole Location Plan



3.2 Laboratory Testing

3.2.1 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 and Envirolab. The test procedures used were generally in accordance with the methods described in BS1377:2022. Details of the specific tests used in each case are given in Table 4, below.

Table 4: Summary of Laboratory Geotechnical Tests Undertaken

TEST	STANDARD	No.
Moisture Content	BS1377-2:2022, Cl. 4	3
Liquid Limit, Plastic Limit, Plasticity Index	BS1377-2:2022, Cl. 5.3/ 6	3
Particle size distribution (wet)	BS1377-2:2022, Cl. 10	1
BRE Suite	BRE SD1:2005	4

The results of the laboratory geotechnical tests are discussed in Section 5 and included in Appendix 2.

3.2.2 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 6no. 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, Speciated Petroleum Hydrocarbons and Speciated Polyaromatic Hydrocarbons (PAH).

A total of 1no. soil samples was additionally submitted for Waste Acceptance Criteria (WAC) testing.

Complete results of the laboratory contamination tests are discussed in Section 7 and included in Appendix 3.

Additionally, chemical analyses were also carried out on 2no. groundwater samples, which were submitted for the following suite of determinants:

Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Hexavalent Chromium, Copper, Lead, Mercury, Nickel, Selenium, Vanadium, Zinc, Cyanide, Phenol, Sulphate (SO₄), Sulphide, pH, Total Organic Carbon (TOC), Extractable Petroleum Hydrocarbons (EPH), Speciated Petroleum Hydrocarbons (TPH), Speciated Polyaromatic Hydrocarbons (PAH) and BTEX.

The results of the laboratory water contamination tests are discussed in Section 8 and included in Appendix 5.

4.0 GROUND CONDITIONS ENCOUNTERED

4.1 Local Recorded Geology

BGS digital mapping shows that the site is underlain by superficial Devensian Till deposits, comprising Diamicton, i.e. clay and sand with occasional boulders.

The bedrock geology beneath the site is shown to be the Chester Formation, comprising Triassic sandstone.

4.2 Soil Profile Encountered

The sequence of strata identified on site is as follows:

- **Made Ground** was encountered in all exploratory boreholes between ground level and to a maximum depths between 2.30m and 6.00m bgl, generally comprising:
 - Asphalt.
 - Concrete.
 - Dark brown CLAY, with variable quantities of sand and gravel of red brick, concrete, clinker, glass, plastic, metal, limestone, sandstone and mudstone.
 - COBBLES of red brick.
 - Light grey GRAVEL, with variable quantities of clay and sand. Gravel comprising red brick, concrete and sandstone.
 - Light grey SAND, with variable quantities of clay and gravel of red brick, concrete and sandstone.
- **Superficial Deposits** were encountered exclusively within WS01, between 2.30m and 3.70m bgl, generally comprising:
 - Stiff brown, slightly sandy slightly gravelly CLAY, with gravel comprising mudstone.

The depths of the various materials encountered in the exploratory holes are summarised in Table 5, overleaf.

It should be noted that in all exploratory hole locations, other than WS01, a loss of recovery was observed within the deeper made ground. It is assumed that this is due to cobbles displacing the material during drilling. As a result of this, logical interpretations of the ground conditions have been made in these areas of poor recovery. Full details of the exploratory hole logs are provided in Appendix 1.

4.3 Observable Indications of Contamination

Although significant made ground was observed across the site, no observable indication of visual or olfactory contamination was encountered.

4.4 Obstructions

No sub-surface obstructions were encountered during the site investigation.

4.5 Groundwater

Groundwater, assumed to be perched, was encountered during the ground investigation within WS03 and WS04 at 5.00m bgl.

Subsequent monitoring visits identified perched groundwater in both installed boreholes (WS02 & WS04) at depths between 3.66m and 4.98m bgl.

Table 5: Summary of Ground Conditions Encountered

Hole	Depth to Stratum (m bgl)				Investigation Groundwater (m bgl)	Monitoring Groundwater (m bgl)
	MADE GROUND			CLAY		
	HARDSTANDING	GRANULAR	COHESIVE			
WS01	-	-	GL - 2.30	2.30 - 3.70+	-	-
WS02	GL - 0.19	0.19 - 0.35	0.35 - 6.00+	-	-	4.04 - 4.98
WS03	GL - 0.02	0.02 - 0.38 1.00 - 1.30	0.38 - 1.00 1.30 - 6.00	-	5.00	-
WS04	GL - 0.05	0.05 - 0.22 0.80 - 3.00	0.22 - 0.80 3.00 - 6.00	-	5.00	3.66 - 4.43

5.0 ENGINEERING PROPERTIES OF SOILS ENCOUNTERED

5.1 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 Table 6.

Table 6: Summary of Laboratory Geotechnical Test Results

LOCATION	DEPTH	MATERIAL	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Passing 425µm (%)	Modified Plasticity Index	PSD Gravel (%)	PSD Sand (%)	PSD Silt (%)	PSD Clay (%)	pH Value	Water Soluble Sulphate SO ₄ (mg/l)
WS01	2.40	CLAY	21.5	36	14	22	98	22	-	-	-	-	7.89	21
WS01	2.80	CLAY	17.5	38	13	25	96	24	2	14	68	16	-	-
WS01	3.60	CLAY	15.9	37	14	23	96	22	-	-	-	-	-	-
WS02	2.10	MG	-	-	-	-	-	-	-	-	-	-	8.19	33
WS03	3.10	MG	-	-	-	-	-	-	-	-	-	-	7.90	19
WS03	4.10	MG	-	-	-	-	-	-	-	-	-	-	7.93	25

5.2 Made Ground

Made ground, varying between granular and cohesive in nature, was encountered in all exploratory borehole locations between ground level and to a maximum depth of 6.00m below ground level.

SPT tests carried out in the made ground resulted in **SPT N values** between 2 and 14, as shown on the SPT v Depth Plot in Figure 5 (overleaf).

BRE SD1 testing has been conducted on 3no. made ground samples. The **water-soluble sulphate** content ranged from 19mg/l to 33mg/l SO₄, together with **pH values** of 7.9 to 8.19.

5.3 Superficial Deposits

As discussed in Section 4, superficial material was encountered as variable clay exclusively within WS01, at a depth of 2.30m to 3.70m bgl.

5.3.1 Clay

SPT tests carried out in the clay resulted in **SPT N values** of 27 and 50, as shown on the SPT v Depth Plot in Figure 5 (overleaf). This result suggests the clay is stiff to very stiff.

Atterberg Limit tests were carried out on 3no. samples of the clay. The test results reported liquid limit values in the range of 36% to 38% and plastic limit values in the range of 13% to 14%, resulting in a plasticity index of 22% to 25%. These results suggest the clay to be of **intermediate plasticity**. Results are shown on the Plasticity Chart in Figure 6, overleaf.

BRE SD1 testing has been conducted on 1no. sample of the clay. The **water-soluble sulphate** content of the tested sample was reported as 21mg/l SO₄, together with a **pH value** of 7.89.

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

Table 7: Summary of Design Parameters (Clay)

Depth	SPT N Value Range	Design N Value*	Equivalent Shear Strength** (kN/m ²)	Coefficient of Volume Compressibility** (mv)
3.00	27	27	136.35 (High Strength)	0.07 (Low Compressibility)
4.00	50	50	252.5 (Very High Strength)	0.04 (Very Low Compressibility)
*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 between 136.35 and 252.5 kN/m².

For design purposes, a value of plasticity index = 24% is recommended, based on the upper quartile value 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 24%, mv = 1 / (0.505 x N value). This correlation gives a value of coefficient of volume compressibility of 0.07 to 0.04m²/MN, as shown in Table 7, above. The results suggest the clay has a **low to very low 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 a **medium volume change potential**.

The **Natural Moisture Content (NMC)** and **Liquid Limit (LL)** of the soil can be used to indicate soil desiccation. Specifically, when the NMC is less than 40% of the LL, the soil is inferred to be desiccated, as summarised in Table 8 below.

Table 8: Soil Desiccation Indicators in Clay

Location	Depth (m)	Liquid Limit (%)	40% Liquid Limit (%)	Natural Moisture Content (%)	Desiccation
WS01	2.40	36	14	21.5	No
WS01	2.80	38	15	17.5	No
WS01	3.60	37	15	15.9	No

The results in the above table show that none of the clay samples tested show evidence of desiccation.

Figure 5: SPT v Depth Plot

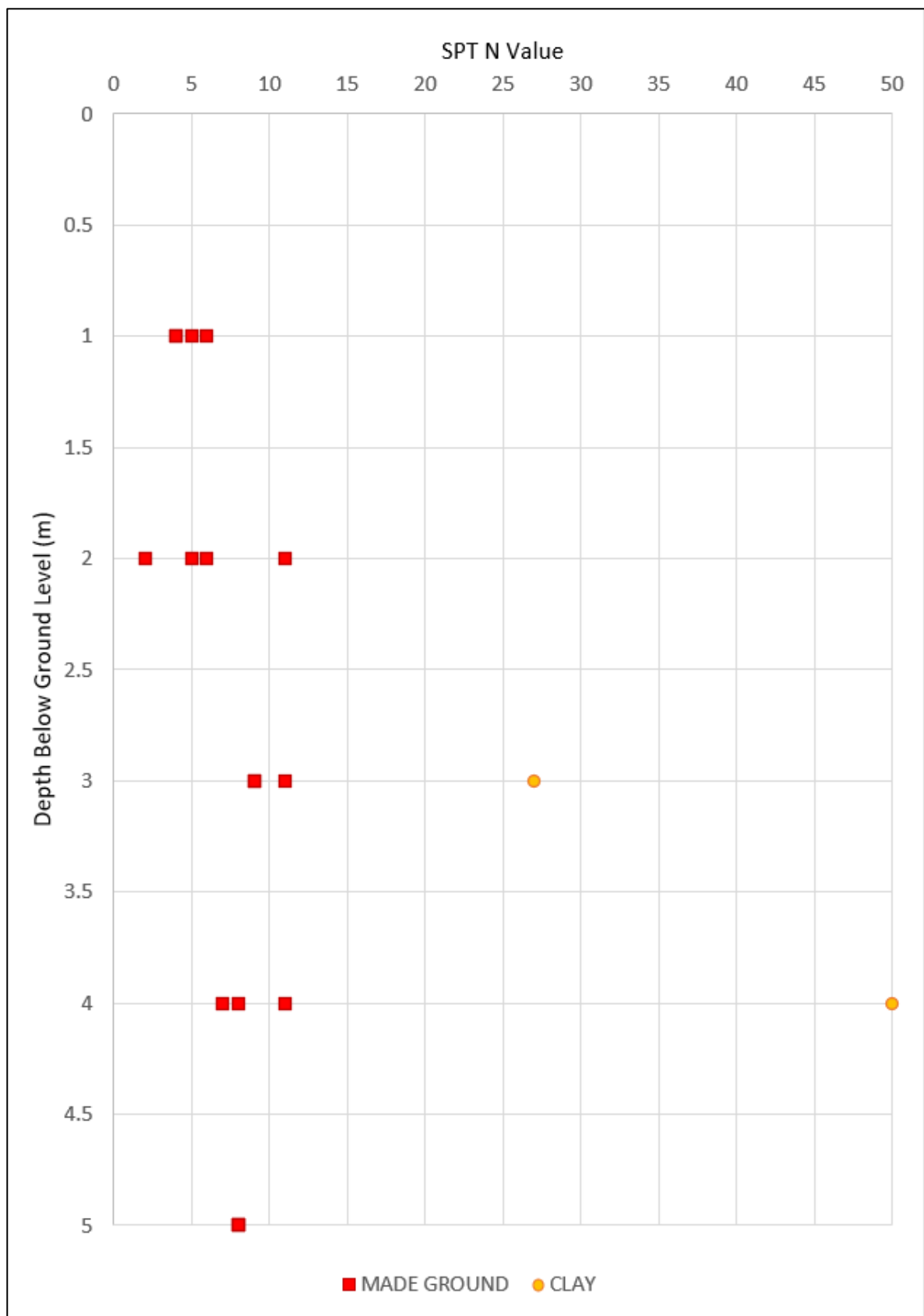
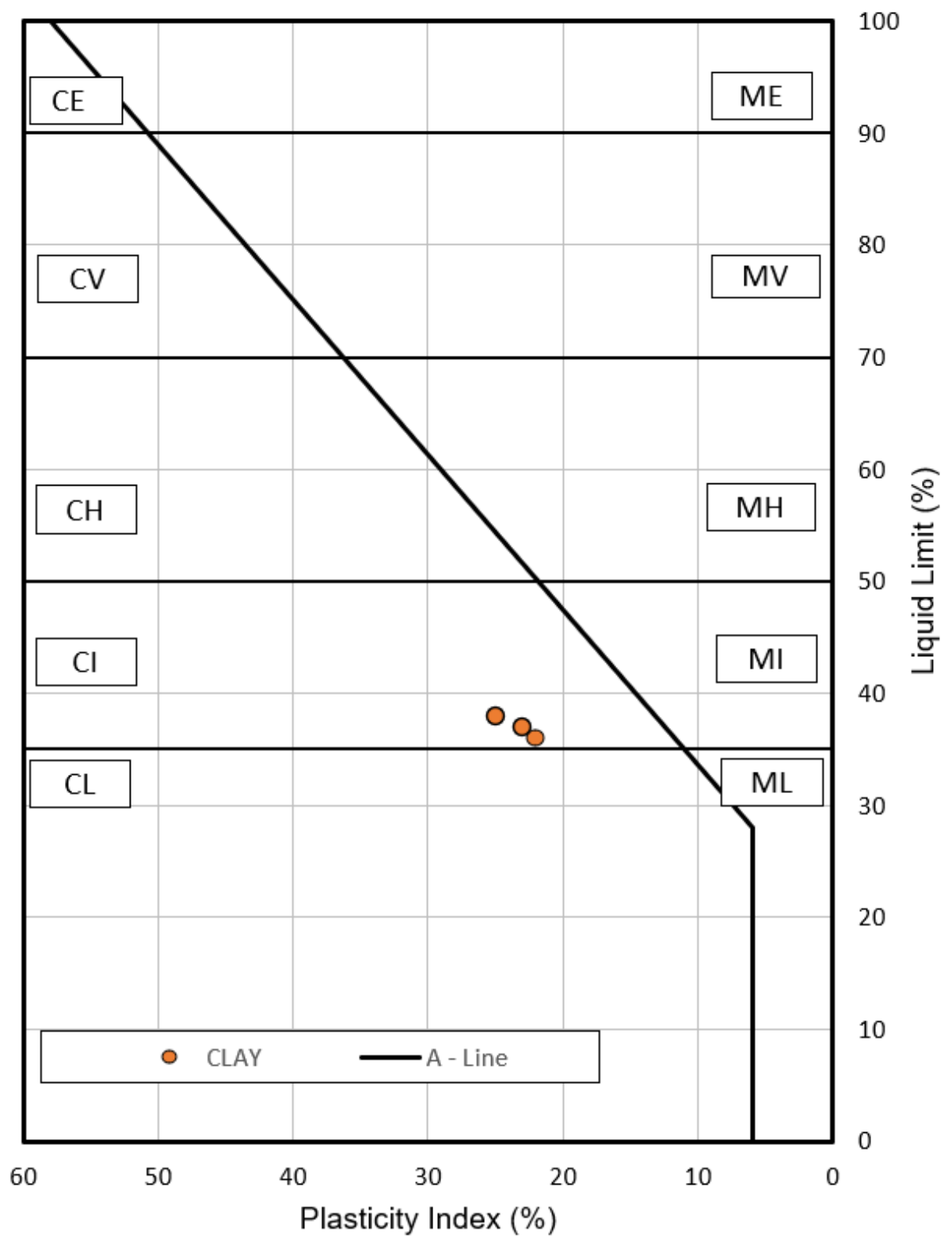


Figure 6: Plasticity Chart



6.0 GEOTECHNICAL ASSESSMENT

6.1 Proposed Development

It is understood the client is proposing to construct a new single storey commercial building, comprising 2no. units, along with associated alterations to the car parking layout.

Detailed information regarding structural loadings was not available at the time of authoring this report.

6.2 Ground Conditions Encountered

The exploratory holes generally encountered variable made ground between ground level and a maximum identified depth of 6.00m bgl. Natural clay deposits were identified in one location (WS01 on the northern boundary of the site) between 2.30m and to a maximum identified depth of 3.70m bgl.

Groundwater was encountered during the ground investigation exclusively within WS03 and WS04 at 5.00m bgl. Subsequent monitoring visits identified groundwater in both installed boreholes (WS02 and WS04) at depths between 3.66m and 4.98m bgl. Considering the ground conditions, it is assumed the encountered water is perched within the made ground.

6.3 Foundation Considerations

Based on the ground conditions encountered, i.e deep, variable made ground, conventional shallow depth foundations (strip/pad or trench fill), are not considered suitable for the proposed development. Therefore, alternative foundation solutions should be considered, such as a piles.

6.3.1 Piled Foundations

Due to the deep and variable nature of the encountered made ground, driven or bored piles could be adopted. Driven piles would have the advantage of minimising the spoil that is generated; however, the noise and vibration associated with the installation of driven piles may prevent this type of pile from being selected. It should also be noted that driven piles can also potentially create preferential pollutant pathways.

Short bored (cast in-situ) piles installed using continuous flight auger (CFA) techniques may therefore be more appropriate but given 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 made ground.

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 is capable of providing the required working loads in the ground conditions encountered.

6.3.2 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 is capable of providing the required working loads in the ground conditions encountered, with a guarantee on maximum settlement for both footings and floor slabs.

6.3.3 Controlled Modulus Columns

Where traditional ground improvement techniques may not be suitable due to either poor soil strength, high loadings or tight settlement criteria, controlled modulus columns (CMCs) provide a fast and economical ground improvement alternative to piling.

The technique installs low strength concrete columns, 280mm to 500mm in diameter, up to 50m in depth using displacement tools.

The benefits are:

- Ground bearing foundation solution utilising a distribution mattress.
- The rig working platform can be used as part of the distribution mattress.
- No breaking down of CMCs. Trimming is undertaken while the CMCs are still wet.
- The vibration free displacement process creates minimal spoil.

The technique can be used for a wide range of structures including heavily loaded commercial/industrial floor slabs, road and rail embankments, silos, tanks and wind turbines and residential buildings traditionally founded on driven piles.

Positive assurances should be sought from an experienced specialist contractor that the proprietary system proposed is capable of providing the required working loads in the ground conditions encountered, with a guarantee on maximum settlement for both footings and floor slabs.

6.4 Pavement Design

The ground investigation identified the soil type at the subgrade level to typically be made ground. Based on the recommendations for design CBR values provided in Interim advice note 73/06, Revision 1 (2009), a conservative design CBR value of 1% should be adopted in areas where made ground is encountered at subgrade level.

Consideration should be given to the potential differing ground conditions near the 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 reduce capping thickness. For example, 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 that the type of construction will depend on the proposed finished pavement levels across the site, and it is recommended that the pavement design be reviewed once these levels are known. In this context, it is essential that further in situ CBR testing is carried out once formation levels are known to confirm design CBR values.

Table 9: 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.

6.5 Chemical Attack on Buried Concrete

Chemical tests (see Appendices) show low levels of water-soluble sulphates and generally neutral conditions, although several of the tested made ground samples are more alkaline. 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.

6.6 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.

Granular made ground and natural sand 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.

6.7 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.

7.0 SOIL CONTAMINATION RISK ASSESSMENT

7.1 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 10: Summary of Guideline Values for Protection of Workers and the General Public During the Development of Contaminated Land

Determinant	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	-	-
pH (alkaline)	7 - 8	8 - 9	9 - 10	10 - 12	12	7.8 - 12.4	A - E
Arsenic	0 - 30	30 - 50	50 - 100	100 - 500	500	8.1 - 31	A - B
Cadmium	0 - 1	1 - 3	3 - 10	10 - 50	50	0.2 - 0.6	A
Chromium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	12 - 23	A
Copper	0 - 100	100 - 200	200 - 500	500 - 2500	2500	51 - 78	A
Lead	0 - 500	500 - 1000	1000 - 2000	2000 - 1%	1.0%	55 - 150	A
Mercury	0 - 1	1 - 3	3 - 10	10 - 50	50	0.10 - 0.45	A
Nickel	0 - 20	20 - 50	50 - 200	200 - 1000	1000	12 - 35	A - B
Zinc	0 - 250	250 - 500	500 - 1000	1000 - 5000	5000	47 - 210	A
Boron	0 - 2	2 - 5	5 - 50	50 - 250	250	0.3 - 0.8	A
Selenium	0 - 1	1 - 3	3 - 10	10 - 50	50	<0.5	A
Barium	0-500	500-1000	1000-2000	2000-1.0%	1.0%	90 - 190	A
Beryllium	0 - 5	5 - 10	10 - 20	20 - 50	50	0.5 - 1.6	A
Vanadium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	21 - 43	A
Sulphate	0 - 2000	2000 - 5000	5000 - 1%	1% - 5%	5.05%	400 - 2500	A - B
Sulphide	0 - 10	10 - 20	20 - 100	100 - 500	500	<10 - 48	A - C
Cyanide (free)	0 - 1	1 - 5	5 - 50	50 - 100	100	<0.1	A
Phenol	0 - 2	2 - 5	5 - 50	50 - 250	250	<0.3 - 9.6	A - C

Based on the above results, the soils generally range from uncontaminated to contaminated, however the alkaline pH of one sample is classified as unusually heavily contaminated. Therefore, there is a **MODERATE to 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 further mitigate any risk.

7.2 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 contaminated land guidance has recently changed the evaluation of risk from 'minimal' (SGVs) to 'low' (referred to as Lowest Level of Toxicological Concern (LLTCs)). The policy companion document and supporting letter by DEFRA, states that C4SLs 'could be used under the planning regime, as well as within Part 2A'.

Based on these comments EEG considers the justifications and assumptions used to generate 'low' risk are suitable for the planning regime.

Where no C4SLs have been generated EEG will use the LQM S4ULs. Similar assumptions and land use to C4SLs have been used. However, toxicological information has been based on 'minimal risk' as per previous guidelines and assumptions. If contaminants are not present as C4SLs or S4ULs then EEG will use CL:AIRE GACs. These follow the 'minimal' risk principal and more stringent exposure parameters and will be conservative.

EEG consider the main risk drivers for PAHs are benzo(a)pyrene (B(a)P) and naphthalene.

This is due to B(a)P possibly being a carcinogen and most toxic of the PAHs and naphthalene the most volatile and soluble. The new C4SLs indicate B(a)P as a surrogate marker for carcinogenic PAHs, since the risk from other non-carcinogenic PAHs are considered negligible. Naphthalene will be treated separately using the Defra C4SL (2024).

As a preliminary screening assessment, all results have been compared to **commercial end use** criteria at 1% soil organic matter content.

The soil chemical testing results are summarised in Table 11, overleaf.

Table 11: Soil Results Comparison with C4SL/S4UL Values

Determinant	C4SL/S4UL Levels Commercial SOM 2.5% (mg/kg)	WS01 0.35m	WS01 1.20m	WS02 2.50m	WS03 0.80m	WS04 0.50m	WS04 0.90m	No of Exceedances
Metals								
Arsenic	640	8.1	26	11	31	20	16	0
Beryllium	12	0.5	1.2	0.7	1.6	0.6	0.7	0
Boron	240000	0.5	0.8	0.4	0.6	0.8	0.3	0
Cadmium	190	0.2	0.2	0.2	0.6	0.2	0.2	0
Chromium	8600	16	20	14	23	12	19	0
Chromium VI	33	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	0
Copper	68000	51	62	71	78	53	63	0
Lead	2300	55	110	150	150	110	120	0
Inorganic Mercury	5100	0.10	0.24	0.45	0.20	0.37	0.43	0
Nickel	980	12	24	18	35	14	23	0
Selenium	12000	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0
Vanadium	9000	29	38	21	43	23	28	0
Zinc	730000	66	76	59	210	47	85	0
Polycyclic Aromatic Hydrocarbons								
Naphthalene	3700	0.36	0.49	0.10	0.19	32	23	0
Acenaphthylene	97000 ^{sol}	0.27	< 0.10	< 0.10	0.15	5.0	< 2.00	0
Acenaphthene	97000 ^{sol}	1.2	1.9	< 0.10	0.32	5.0	67	0
Fluorene	68000	1.6	1.6	0.15	0.50	13	94	0
Phenanthrene	22000	10	9.8	0.46	4.3	69	370	0
Anthracene	540000	2.8	2.4	0.64	1.1	14	72	0
Fluoranthene	23000	11	7.6	0.90	6.5	48	270	0
Pyrene	54000	13	8.7	1.6	7.2	54	270	0
Benzo(a)anthracene	170	4.5	3.5	0.51	3.5	23	110	0
Chrysene	350	4.8	3.9	0.50	3.7	26	120	0
Benzo(b)fluoranthene	44	3.6	2.3	0.40	2.7	14	73	1
Benzo(k)fluoranthene	1200	2.0	1.4	0.24	1.6	8.8	42	0
Benzo(a)pyrene	77	5.4	3.8	0.65	3.9	22	100	1
Indeno(1,2,3-cd) pyrene	510	3.1	2.1	0.37	2.4	13	61	0
Dibenzo (a, h) anthracene	3.6	0.30	0.25	< 0.10	0.34	1.8	7.0	1
Benzo(ghi)perylene	4000	2.9	1.9	0.32	1.9	10	45	0
Petroleum Hydrocarbons								
Aliphatic EC >5-6	5900 ^{sol}	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Aliphatic EC >6-8	17000 ^{sol}	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Aliphatic EC >8-10	4800 ^{vap}	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Aliphatic EC >10-12	23000 ^{vap}	< 1.50	< 1.50	1.84	< 1.50	< 1.50	< 1.50	0
Aliphatic EC >12-16	82000 ^{sol}	< 1.20	< 1.20	1.44	< 1.20	< 1.20	< 1.20	0
Aliphatic EC >16-21	1700000	< 1.50	< 1.50	< 1.50	< 1.50	< 1.50	< 1.50	0
Aliphatic EC >21-35	1700000	< 3.40	< 3.40	< 3.40	< 3.40	< 3.40	< 3.40	0
Aromatic EC >5-7	46000 ^{sol}	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Aromatic EC >7-8	110000 ^{sol}	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Aromatic EC >8-10	8100 ^{vap}	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Aromatic EC >10-12	28000 ^{sol}	< 0.90	< 0.90	< 0.90	< 0.90	36.85	5.22	0
Aromatic EC >12-16	37000	0.80	1.58	< 0.50	< 0.50	54.63	46.14	0
Aromatic EC >16-21	28000	7.19	4.45	1.68	2.24	122.9	116.5	0
Aromatic EC >21-35	28000	21.98	< 1.40	< 1.40	< 1.40	92.90	76.69	0
Benzene	50	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Toluene	110000 ^{vap}	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Ethylbenzene	13000 ^{vap}	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
m-xylenes	14000 ^{vap}	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
p-xylenes	14000 ^{sol}	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
o-xylenes	15000 ^{sol}	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Phenols								
Phenol	690 ^{dfr}	< 0.3	< 0.3	< 0.3	< 0.3	0.5	9.6	0



Based on the above table, 3no. contaminant concentrations were found in exceedance of the screening criteria relevant to a commercial end use. This refers to exceedances of benzo(b)fluoranthene, benzo(a)pyrene and dibenz(a,h)anthracene in the sample tested from WS04 at 0.90m bgl.

Asbestos fibres were not identified during the site investigation.

7.3 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 12 below and presented in full in Appendix 4.

Table 12: Waste Classification of Soils

Location	Depth (m bgl)	WM3.1 Classification	WAC Testing Classification	Comments
WS01	0.35	Hazardous	-	Elevated pH (alkaline)
WS01	1.20	Non-Hazardous	-	-
WS02	2.50	Non-Hazardous	-	-
WS03	0.80	Non-Hazardous	-	-
WS04	0.50	Non-Hazardous	Exceeds Hazardous	Elevated TOC, LOI, mineral oil & PAHs
WS04	0.90	Non-Hazardous	-	-

The above table shows that 1no. of the tested samples collected from the site has been classified as **Hazardous** in accordance with WM3.1 due to elevated pH (alkaline). All remaining samples have been classified as **Non-Hazardous** in accordance with WM3.1.

1no. of the soil samples has been submitted for Waste Acceptance Criteria (WAC) testing. The sample tested from WS04 at 0.50m bgl contained concentrations of Total Organic Carbon (TOC), Loss on Ignition (LOI) above the acceptable limits for disposal at a hazardous waste landfill, as well as concentrations of mineral oil and Total PAHs above the acceptable limit for disposal at an inert waste facility.

We recommend that local landfills and waste facilities should be consulted prior to the removal of any material from the site.

For Waste Acceptance Criteria (WAC) testing, EEG have compared solid waste and leachate values with guideline values in Landfill Regulations. The following table summarises the results of the solid waste analysis and leachate testing, together with limit values for Non-Hazardous waste and Hazardous waste as described in the Landfill Regulations.

Table 13: Summary of WAC Test Results

Determinant	Landfill Regulations Limits (mg/kg unless otherwise indicated)			WS04 0.50m (mg/kg)
	Inert Waste	Stable non-reactive hazardous waste	Hazardous Waste	
TOC (%)	3%	5%	6%	6.3
Loss on ignition (%)	-	-	10%	10.0
BTEX (mg/kg)	6	-	-	< 0.04
Sum of PCBs (mg/kg)	1	-	-	< 0.01
Mineral Oil (mg/kg)	500	-	-	25000.0
Total PAH (mg/kg)	100	-	-	310.0
pH (units)	-	< 6	-	8.2
Acid Neutralisation Capacity (mol/kg)	-	<i>To be evaluated</i>		<1
Arsenic	0.5	2	25	0.03
Barium	20	100	300	< 0.1
Cadmium	0.04	1	5	< 0.02
Chromium	0.5	10	70	< 0.1
Copper	2	50	100	< 0.02
Mercury	0.01	0.2	2	< 0.002
Molybdenum	0.5	10	30	< 0.1
Nickel	0.4	10	40	< 0.1
Lead	0.5	10	50	< 0.05
Antimony	0.06	0.7	5	< 0.05
Selenium	0.1	0.5	7	< 0.03
Zinc	4	50	200	0.01
Chloride	800	15000	25000	< 100
Fluoride	10	150	500	< 0.1
Sulphate	1000	20000	50000	< 100
Total Dissolved Solids	4000	60000	100000	210
Phenol Index	1	-	-	< 1
DOC	500	800	1000	< 50



8.0 GROUNDWATER CONTAMINATION 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 Quality standards ⁽²⁰⁰⁰⁾.

EQS values have been derived to protect surface water. For this report, the most appropriate EQS data are those established for freshwater.

Many of the EQS values lie just above the method detection limit for parameters and, as such, are highly conservative.

In the absence of EQS values, Drinking Water Quality standards have been used for comparison of results. Again, these standards are highly conservative, especially in this site context.

A total of 2no. groundwater samples were retrieved from the monitoring wells installed in the boreholes drilled in the proposed development area.

A direct comparison was made between the groundwater analysis results and the EQS and Drinking Water Quality standards. Table 14 shows that the laboratory analyses identified multiple determinants with values above the EQS/ Drinking Water Quality standards.

Although exceedances of the conservative EQS and DWQ criteria have been identified, in some cases by orders of magnitude, given the historical and current commercial use of the site and the surrounding area, these concentrations are interpreted as background levels for this report.

As detailed in the Phase 1 GeoEnvironmental Desk Study, there are no surface water features, surface water abstractions or active potable water abstractions within 250m of the site. Additionally, the closest active groundwater abstraction licence is located 215m southeast of the site. The local superficial deposits are classified as a low vulnerability Secondary Undifferentiated Aquifer, and although the bedrock deposits are classified as a Principal Aquifer, they are also recorded as low vulnerability.

Considering the low permeability of the observed and locally recorded superficial till deposits, as well as the likelihood of contaminant migration into the underlying principal bedrock aquifer (the only relevant sensitive receptor), the risk to controlled waters is interpreted as **LOW**.

Table 14: Groundwater Results Comparison with EQS/Drinking Water Quality Values

Determinant	Threshold Value	WS02 (05.01.2026)	WS04 (05.01.2026)	No. of Exceedances
Arsenic	50 ^(A) (EQS)	4.69	2.53	0
Barium	700 (WHO) (DWQ)	188.6	112.2	0
Beryllium	-	< 0.10	< 0.10	0
Boron	2000 ^(A) (EQS)	131.9	99.66	0
Cadmium	0.9 ^(M) (EQS)	< 0.03	0.03	0
Chromium	32 ^(M) (EQS)	< 0.25	< 0.25	0
Chromium VI	3.4 ^(A) (EQS)	< 7.0	< 7.0	0
Copper	1.0 ^(A) (EQS)	1.94	1.75	2
Lead	14 ^(M) (EQS)	2.88	0.83	0
Mercury	0.07 ^(M) (EQS)	< 0.01	< 0.01	0
Selenium	10 (DWQ)	0.32	3.48	0
Vanadium	20 ^(A) (EQS)	1.55	2.78	0
Nickel	34 ^(M) (EQS)	1.98	2.92	0
Zinc	10.9 ^(A) (EQS)	74.25	61.98	2
Cyanide	5 ^(M) (EQS)	0.1	< 0.1	0
Phenol	46 ^(M) (EQS)	< 1.5	< 1.5	0
Sulphate	400000 ^(A) (EQS)	41000	57000	0
pH	6 - 9 ^(M) (EQS)	7.1	7.1	0
Naphthalene	130 ^(M) (EQS)	15	61	0
Anthracene	0.1 ^(M) (EQS)	25	58	2
Benzo(a)pyrene	0.27 ^(M) (EQS)	53	94	2
Benzo(b)fluoranthene	0.017 ^(M) (EQS)	67	100	2
Benzo(k)fluoranthene	0.017 ^(M) (EQS)	25	40	2
Indeno(123cd) pyrene	10 (DWQ)	34	55	2
Fluoranthene	0.12 ^(M) (EQS)	170	210	2
Benzene	50 ^(M) (EQS)	< 1.0	< 1.0	0
Toluene	380 ^(M) (EQS)	< 1.0	< 1.0	0
Ethylbenzene	300 (WHO) (DWQ)	< 1.0	< 1.0	0
Xylenes	30 ^(A) (EQS)	< 1.0	< 1.0	0
TPH Aliphatic C5-C6	15000 (WHO) (DWQ)	< 0.1	< 0.1	0
TPH Aliphatic C6-C8	15000 (WHO) (DWQ)	< 0.1	< 0.1	0
TPH Aliphatic C8-C10	300 (WHO) (DWQ)	< 0.1	< 0.1	0
TPH Aliphatic C10-C12	300 (WHO) (DWQ)	< 1.0	< 1.0	0
TPH Aliphatic C12-C16	300 (WHO) (DWQ)	< 1.0	< 1.0	0
TPH Aliphatic C16-C21	300 (WHO) (DWQ)	< 1.0	< 1.0	0
TPH Aliphatic C21-C35	300 (WHO) (DWQ)	< 1.0	< 1.0	0
TPH Aromatic C5-C7	10 (WHO) (DWQ)	< 0.1	< 0.1	0
TPH Aromatic C7-C8	700 (WHO) (DWQ)	< 0.1	< 0.1	0
TPH Aromatic C8-C10	300 (WHO) (DWQ)	< 0.1	< 0.1	0
TPH Aromatic C10-C12	90 (WHO) (DWQ)	< 1.0	< 1.0	0
TPH Aromatic C12-C16	90 (WHO) (DWQ)	< 1.0	< 1.0	0
TPH Aromatic C16-C21	90 (WHO) (DWQ)	< 1.0	< 1.0	0
TPH Aromatic C21-C35	90 (WHO) (DWQ)	< 1.0	< 1.0	0

*All values in µg/l unless otherwise stated, WHO=World Health Organization guide values.

*EQS Standards – (M) = Maximum Allowable Concentration Standard, (A) = Annual Average Standard.

Zinc EQS is based on bioavailability.

8.1 Vapour Risk Modelling

Guidance from the Society of Brownfield Risk Assessment, Development of Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater, Version 1, February 2017.

The SoBRA groundwater vapour assessment criteria are intended as a conservative screening tool that allows assessors to 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).

The assessment criteria 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, soil type in the unsaturated zone, building dimension 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.

Table 15 shows a summary of the chemical test data with the SoBRA aqueous assessment criteria.

The assessment criteria are based on conservative risk modelling by use of the Environment Agency model CLEA 1.07, with the only viable pathway being via vapour inhalation.

Other conservatisms include:

- The assumption that the impacted groundwater / perched water is directly beneath the building, when in fact it may be laterally offset from the receptor.
- The assumption that there is an infinite source term.
- The assumption that there is no biodegradation between the source term and the receptor.
- The assumption that the groundwater source is at a depth of 0.65m below ground level.
- A permeable sandy soil within unsaturated zone, with a soil organic matter of 1%.
- Category 4 Screening Levels exposure parameters with minimal risk HCVs.

Table 15: Groundwater Results Comparison with Screening GAC for Groundwater Vapour Generation Hazard

Parameter	WS02 4.98m	WS04 4.43m	Commercial Assessment Criteria (µg/l)	Exceedance
Acenaphthene	23	51	15,000,000 (sol)	No
Acenaphthylene	11	4.6	20,000,000 (sol)	No
Fluorene	16	52	18,000,000 (sol)	No
Naphthalene	15	61	23,000 (sol)	No
Anthracene	25	58	Not Volatile	-
Benzo(a)pyrene	53	94	Not Volatile	-
Benzo(b)fluoranthene	67	100	Not Volatile	-
Benzo(k)fluoranthene	25	40	Not Volatile	-
Indeno(123cd) pyrene	34	55	Not Volatile	-
Fluoranthene	170	210	Not Volatile	-
Benzene	< 1.0	< 1.0	20,000	No
Toluene	< 1.0	< 1.0	21,000,000 (sol)	No
Ethylbenzene	< 1.0	< 1.0	960,000 (sol)	No
Xylenes*	< 1.0	< 1.0	940,000 (sol)	No
MTBE	< 1.0	< 1.0	7,800,000	No
TPH Aliphatic C5-C6	< 0.1	< 0.1	190,000 (sol)	No
TPH Aliphatic C6-C8	< 0.1	< 0.1	150,000 (sol)	No
TPH Aliphatic C8-C10	< 0.1	< 0.1	5,700 (sol)	No
TPH Aliphatic C10-C12	< 1.0	< 1.0	3,600 (sol)	No
TPH Aliphatic C12-C16	< 1.0	< 1.0	Not Volatile	-
TPH Aliphatic C16-C21	< 1.0	< 1.0	Not Volatile	-
TPH Aliphatic C21-C35	< 1.0	< 1.0	Not Volatile	-
TPH Aromatic C5-C7	< 0.1	< 0.1	20,000,000 (sol)	No
TPH Aromatic C7-C8	< 0.1	< 0.1	21,000,000 (sol)	No
TPH Aromatic C8-C10	< 0.1	< 0.1	190,000 (sol)	No
TPH Aromatic C10-C12	< 1.0	< 1.0	660,000 (sol)	No
TPH Aromatic C12-C16	< 1.0	< 1.0	3,700,000 (sol)	No
TPH Aromatic C16-C21	< 1.0	< 1.0	Not Volatile	-
TPH Aromatic C21-C35	< 1.0	< 1.0	Not Volatile	-

*Criteria for m-xylenes used due to most conservative criteria.

9.0 GROUND GAS AND RADON GAS CONTAMINATION RISK ASSESSMENT

9.1 Radon Gas

The site is located in an area with a maximum radon potential of <1%, as defined by the Health Protection Agency. Therefore, radon protection measures are not required for the proposed development.

9.2 Analyses of Monitoring Results

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

Four monitoring visits have been conducted between the 12th of December 2025 and the 20th of January 2026. The results recorded methane (CH₄) levels of 0.0% v/v, with carbon dioxide (CO₂) levels between 0.1% and 10.0% v/v. Oxygen concentrations between 3.1% and 14.7% v/v were also recorded.

In general, no flow rates were detected during the monitoring period. For assessment purposes, a flow rate of 0.1 litres/hour has been used based on the minimum detection limit of the monitoring instrument.

Atmospheric pressure was recorded between 994mb and 1007mb, with each visit occurring within either a steady or falling pressure system.

Complete results of the monitoring are presented in Appendix 6.

Table 16 overleaf, adapted from Table 1 of the technical paper 'Risk and Reliability in Gas Protection Design' by Card et al. (2019), provides a summary of current UK practice regarding appropriate gas protection measures based on a Gas Screening Value (GSV). A GSV for the site has been obtained by multiplying the maximum gas concentration by the steady flow rate of 0.1 l/h adopted for assessment purposes.

- Carbon dioxide: Steady flow rate = 0.1 l/hr, max concentration = 10.0%
- Methane: Steady flow rate = 0.1 l/hr, max concentration = 0.0%.

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

- **Carbon Dioxide:** $GSV = 0.1 \times 10.0 / 100 = 0.01 \text{ litres/hour}$
- **Methane:** $GSV = 0.1 \times 0.0 / 100 = 0.00 \text{ litres/hour}$

The CIRIA guidance document notes that '...the GSV is a guideline value and not an absolute threshold'.

The above results suggest the site can be given a Characteristic Situation 2, i.e., 'low risk', in accordance with Table 16 overleaf, due to elevated carbon dioxide levels (>5%) present in both boreholes across multiple visits.

Table 16: Characteristic Situation (Wilson et al 2006/2007 modified from Wilson and Card, 1999)

Characteristic Situation	Risk Classification	Gas Screening Value CH₄ or CO₂ (l/hr)	Additional Factors	Typical source of generation
1	Very Low	<0.07	Typically, < 1% methane Typically, < 5% carbon dioxide	Typically made ground
2	Low	<0.7	Borehole air flow rate to not exceed 70l/hr; otherwise, consider increasing to Characteristic Situation 3	Typically made ground
3	Moderate	<3.5		Old landfill, inert waste, flooded mine workings.
4	Moderate to High	<15	Quantitative risk assessment	Mine workings are susceptible to flooding, and the completed landfill
5	High Risk	<70		Mineworking is unflooded and inactive, with shallow workings near the surface.
6	Very High Risk	>70		Recent landfill site

9.3 Detailed Assessment

EEG have made reference to *Ground Gas Information Sheet No.1, Using Ternary Plots for Interpretation of Ground Gas Monitoring Results (July 2018)*, which reports that carbon dioxide is widespread in the sub-surface environment at concentrations of up to 21% and is generated by microbial and geochemical processes. Elevated carbon dioxide concentrations are commonly elevated in Glacial Till, Chalk, River Terrace Gravel, Thanet Sand, Lambeth Group and Made Ground.

It is reported that when monitoring wells are installed in these materials, small volumes of organic material are exposed to oxygen, which results in biological respiration or oxidation of the material, resulting in the production of carbon dioxide. Weathering of pyrites and subsequent reactions of acidic pore water with carbonate material can also cause increased concentrations of carbon dioxide in the monitoring well headspace.

Organic material in Made Ground can also degrade to produce carbon dioxide and or methane, in which case the carbon dioxide may be generated so slowly that it will not be emitted from the ground surface in quantities or at a rate that is sufficient to pose a risk to overlying development.

Based on the above information, the gas monitoring data from this investigation has been analysed with respect to methane, carbon dioxide, oxygen, and nitrogen gas ratios to deduce the potential source of the ground gas, as shown in Figures 7 to 9 overleaf.

Figure 7: Gas Ratio Ternary Plot

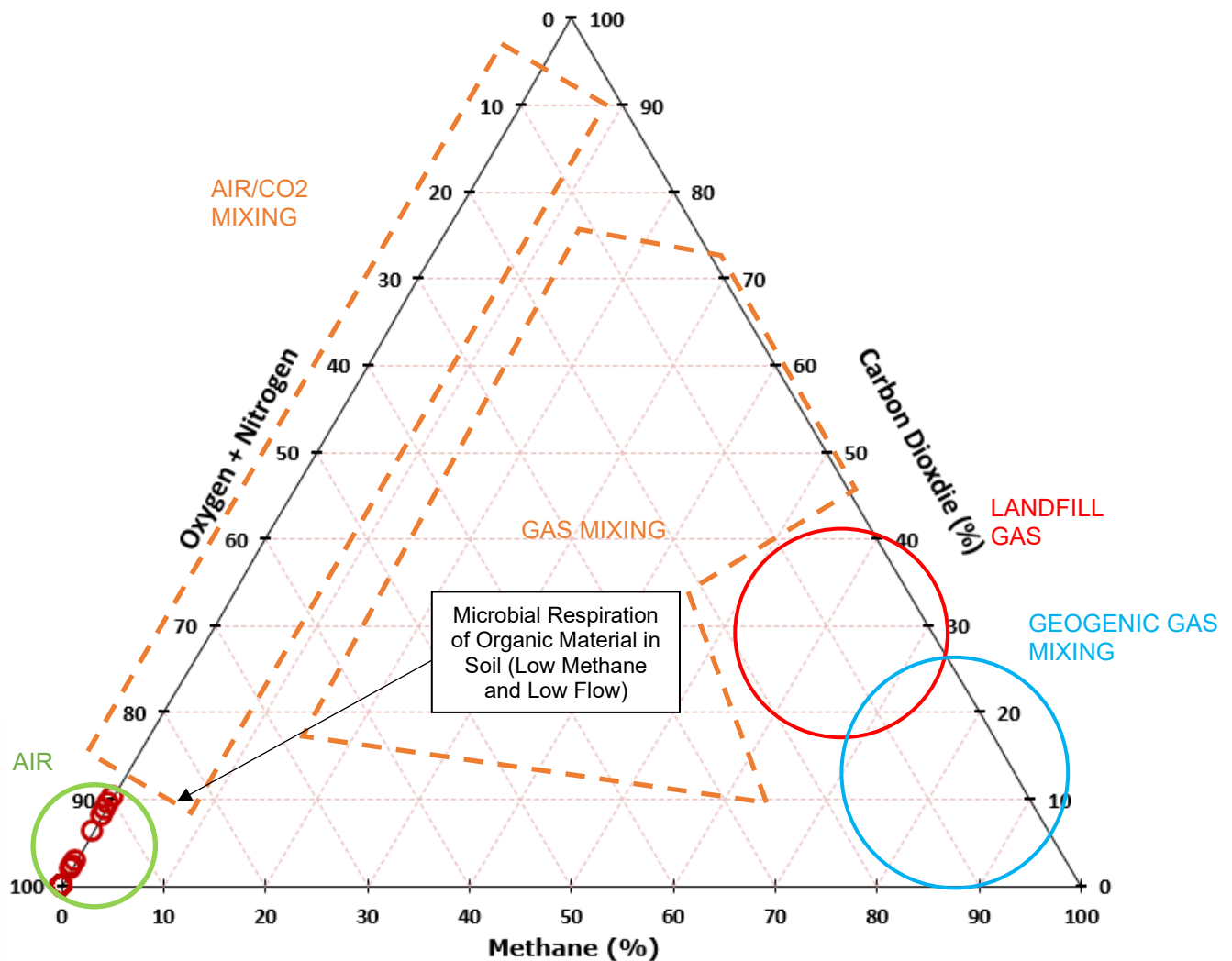


Figure 7 shows the ground gas monitoring results from this site investigation plotted with the gas composition from different sources, adapted from Teasdale et al. 2015. The results show that the gas composition within the monitoring wells at the site is unlikely to be landfill gas. The results generally correspond to air on the gas ratios ternary plot.

Figure 8: Carbon Dioxide: Oxygen Ratio Plot

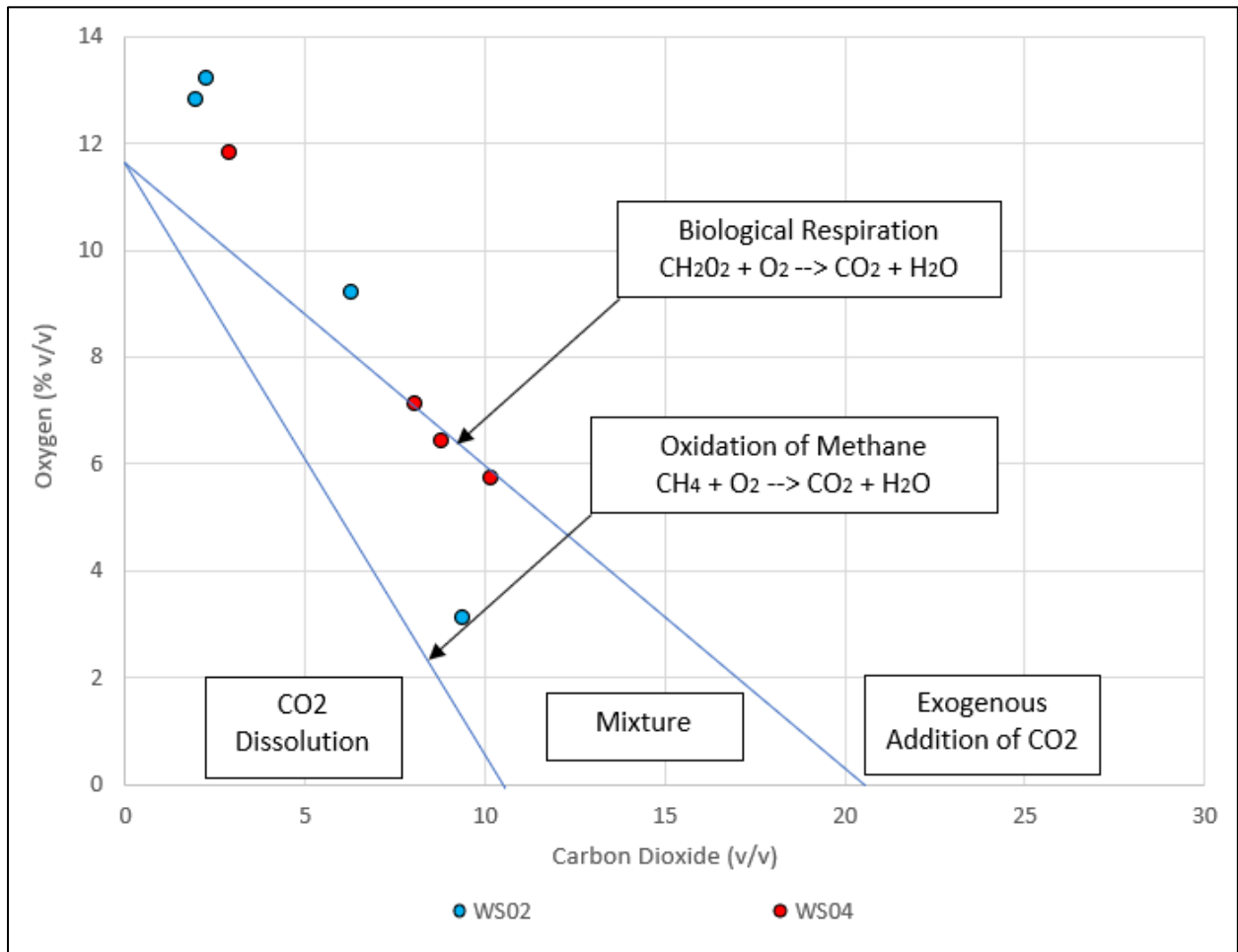


Figure 8 shows that the points that plot to the left of the biological respiration and oxidation of methane lines are caused by dissolution of gas from the ground (or pore) water and from the reaction of rainwater with soil. The points to the right of the biological respiration line are caused by biological respiration (i.e., oxidation of organic material in the soil).

None of the data plots to the left of the oxidation of methane line, and 3no. to the left of the biological respiration line. The majority of the data plots to the right side of the biological respiration line. This indicates that the source of carbon dioxide is likely to be from the oxidation of organic material in the soil, whereas the data plotted to the left indicates a mixture.

Figure 9: Nitrogen/Oxygen: Carbon Dioxide Ratio Plot

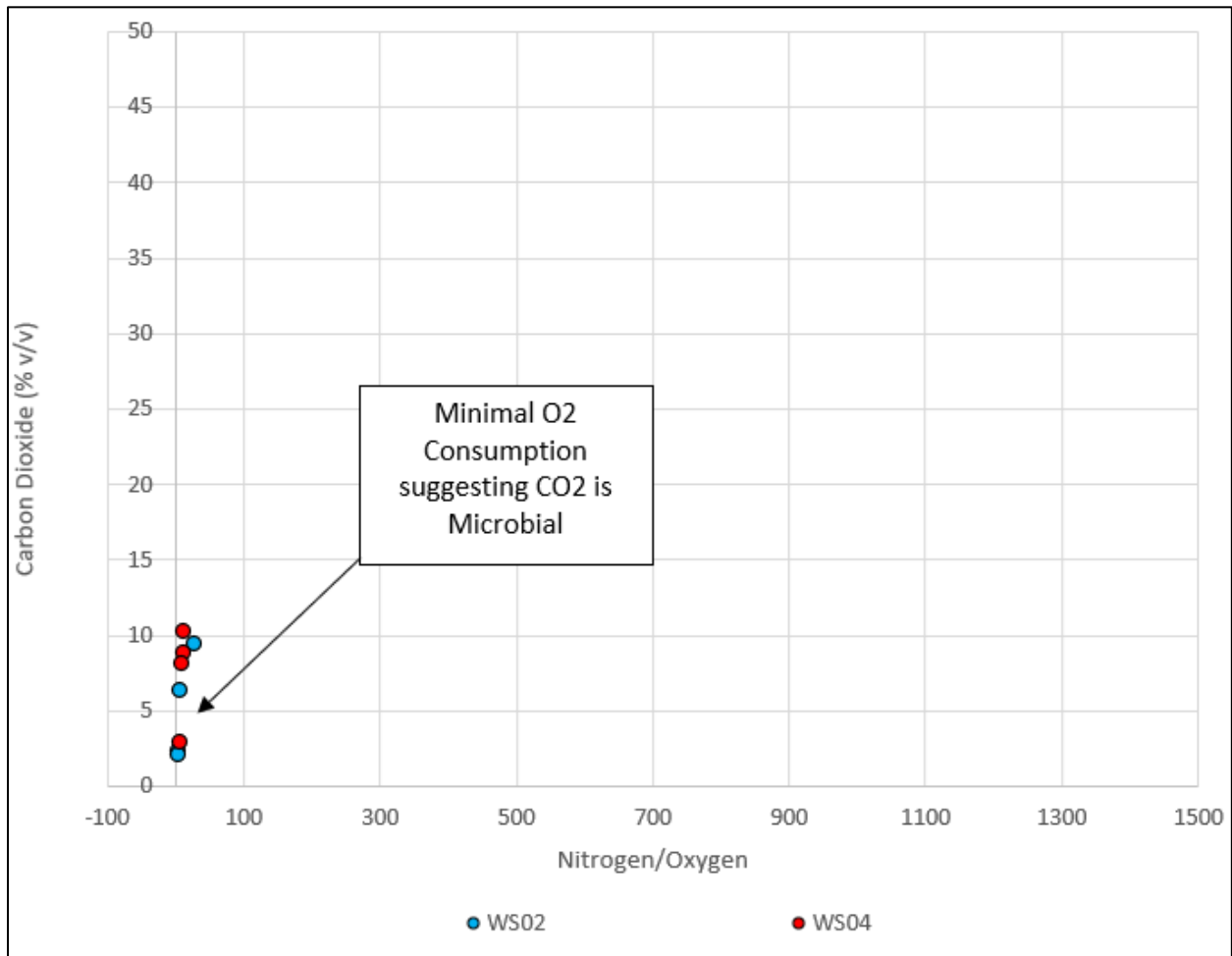


Figure 9 presents an assessment of the nitrogen/oxygen and carbon dioxide ratios. The figure shows all the monitoring results plotted on the left side of the graph, which represents minimal oxygen consumption. There is no data plotting towards the right side of this figure, which would suggest methane oxidation.

The above results and assessment suggest the site can be given a Characteristic Situation 1, i.e., 'very low risk', in accordance with Table 16 above.

Therefore, ground gas protection measures are not considered necessary at the site.

10.0 CONCLUSIONS & RECOMMENDATIONS

10.1 Soil Contamination

There is a **MODERATE to 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.

Based on the results of the chemical testing, 3no. contaminant concentrations, all of which refer to PAHs, were found to exceed the screening criteria relevant to a commercial end use.

No soft landscaping is proposed as part of this development, the entire site will be covered by hardstanding or building footprint. Therefore there is no potential pathway between future end users and the identified elevated determinants.

Therefore, the risk to future end users is **LOW** and no further action is considered necessary.

10.2 Asbestos in soils

No asbestos fibres or fragments have been identified within the soil samples analysed.

10.3 Soil Disposal

Soils should be disposed of at a suitable site, registered to take the levels of contamination encountered. 1no. of the tested soil samples has been classified as **Hazardous** for the purpose of off-site disposal in accordance with Environment Agency guidance WM3.1, due to an elevated alkaline pH. All remaining soil samples have been classified as **Non-Hazardous** for the purpose of off-site disposal in accordance with Environment Agency guidance WM3.1.

Further Waste Acceptance Criteria testing conducted on 1no. of the soil samples (WS04 at 0.50m bgl) identified concentrations of Total Organic Carbon (TOC) and Loss on Ignition (LOI) above the acceptable limits for disposal at a hazardous waste facility, as well as concentrations of mineral oil and Total PAHs above the acceptable limit for disposal at an inert waste facility.

It is recommended that local landfills and waste disposal facilities are consulted before disposing of any soils.

10.4 Groundwater Assessment

Perched water samples have been collected and tested for a wide range of potential contaminants of concern. A preliminary assessment of the measured concentrations using conservative assessment criteria shows multiple determinants exceeded the relevant EQS/Drinking Water threshold values in both tested samples, including copper, zinc and PAHs.

Considering the historical and current industrial/ commercial use of the site and the larger surrounding area, for this report, the identified determinant concentrations are considered background levels. Additionally, there is a general lack of sensitive receptors in the vicinity of the site. The risk to controlled waters is therefore interpreted as **LOW**.

A vapour risk assessment has been undertaken utilising chemical testing data from obtained groundwater samples from the site. None of the tested samples contained concentrations of volatile determinants above the vapour generation hazard assessment criteria relevant for commercial end use.

10.5 Ground Gas

The site is located in an area with a maximum radon potential of <1%, as defined by the Health Protection Agency. Therefore, radon protection measures are not required for the proposed development.

Detailed assessment of the data, with specific reference to gas ratios shows that the ground gas composition generally resembles air, not landfill or harmful gas. No oxidation of methane is occurring at the site. The source is likely to be biological respiration (i.e., the oxidation of organic material in the soil) that has been disturbed and released during the drilling process.

Based on this analysis and the low flow rates recorded in the window sample boreholes, the risk of ground gas can be considered “very low” with a characteristic situation of CS1. Therefore, ground gas protection measures are not necessary in the proposed buildings on this site.

10.6 Foundations

Based on the ground conditions encountered, conventional shallow strip/pad foundations are not considered suitable for the proposed development, and alternative foundation options should be considered such as piles.

It is recommended that for foundations and ground floor slabs in contact with the made ground, the Design Sulphate Class should be taken as DS-1, and the Aggressive Chemical Environment for Concrete (ACEC) site classification be taken as AC-1.

10.7 Pavement Design

Based on the findings of the site investigation, the soil type at subgrade level was typically made ground. Based on the recommendations for design CBR values provided in Interim advice note 73/06, Revision 1 (2009), a conservative design CBR value of 1% should be adopted in areas where made ground is encountered at subgrade level.

10.8 Risk to Buried (Water) Services

It is considered that, due to the presence of hydrocarbons in the tested soils (EC10 - EC16 TPH fraction in both WS04 samples), standard materials may not be suitable 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).

10.9 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.

10.10 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

SOIL CHEMICAL TESTING RESULTS

APPENDIX 4

SOIL WASTE ASSESSMENT

APPENDIX 5

GROUNDWATER CHEMICAL TESTING RESULTS

APPENDIX 6

GROUND GAS MONITORING DATA

APPENDIX 7

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 2026 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 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.