

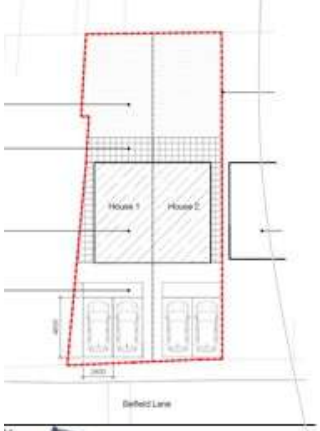





EARTH ENVIRONMENTAL & GEOTECHNICAL

Phase II GeoEnvironmental Investigation

Land Adjacent to 137 Belfield Land

Rochdale

July 2020

On behalf of

Future Construction AA Ltd

Earth Environmental & Geotechnical Ltd
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SITE INVESTIGATION

LAND ADJACENT TO 137 BELFIELD LANE

ROCHDALE

Report Ref: A3539/20/SI

JULY 2020

Prepared on Behalf of:

FUTURE CONSTRUCTION AA LTD

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LAND ADJACENT TO 137 BELFIELD LANE, ROCHDALE

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Version B.0

Date: 31st July 2020

Prepared for: Future Construction AA Ltd

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1.0 EXECUTIVE SUMMARY

Appointment	A Site Investigation has been commissioned by Future Construction AA Ltd to examine ground conditions for a proposed residential development at a site located at Belfield Lane, Rochdale.
The Investigation	The investigation comprised window sample boreholes with associated sampling and in situ testing, laboratory geotechnical and contamination testing.
The Site	The site is located approximately 1.76km north east of Rochdale town centre. The approximate National Grid Reference is SD 91240 13606. At the time of the investigation, the site was a partially developed plot of land with residential dwellings in the process of being constructed.
Site History	The site was part of the Belfield Print Works from the late 1800's to 1954. The site was later used for unspecified industrial works from 1967 to 1976. These works were then demolished, with residential developments surrounding the now vacant site by 1995.
Ground Conditions Encountered	The exploratory holes encountered variable Made Ground (up to 6.00m thick) overlying stiff clay (only encountered in WS07). Groundwater was not encountered during the fieldwork.
Geotechnical Assessment	Recommended foundation option is for a piled foundation solution. Pavement Design – preliminary design value = 1% in Made Ground Design Sulphate Class = DS-1 ACEC Site Classification = AC-1s
Contamination Assessment	Risk from contamination to groundworkers during development – Moderate to Low. Risk from contamination to future site users – Moderate. Soil Waste Assessment: All samples tested were classified as Non-Hazardous.
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 Future Construction AA Ltd to examine ground conditions for two proposed new residential properties at a site in adjacent to 137 Belfield Road, Rochdale.

2.2 Previous Investigations

2.2.1 Earth Environmental & Geotechnical Ltd, Phase I GeoEnvironmental Desk Study (A3539/20), dated June 2020

The desk study highlighted that, historically, the site was part of the Belfield Print Works from the late 1800s to 1954. The site was later used for unspecified industrial works from 1967 to 1976. These works were then demolished, with residential developments surrounding the now vacant site by 1995.

The risk from soil contamination to residential end users was considered to be **MODERATE to LOW**. The risk from ground gas to end users was considered to be **LOW**.

An intrusive investigation was recommended in order to carry out geotechnical and contamination testing. Due to the site lying within a Coal Authority Development High Risk Area, a Coal Mining Risk Assessment was noted to be required to accompany any planning application.

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 A3539 /20 dated 24th June 2020. The objectives of this investigation are as follows:

- *Provide factual information on the work undertaken including sampling location plan, borehole logs, geotechnical and chemical testing.*
- *Tier 1 (semi-quantitative) risk assessment will be undertaken. This will compare the concentrations of soil contaminants identified against current and appropriate published guidelines, in relation to identified receptors, e.g. existing/ future end users and site neighbours.*
- *Classification of soil for offsite disposal.*
- *Assessment of ground conditions for foundation 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 approximately 1.76km north east of Rochdale town centre. The approximate National Grid Reference for the centre of the site is SD 91240 13606 (X: 391240, Y: 413606) with the closest postcode being OL16 2UU.

The site is irregular in shape with maximum dimensions of approximately 27m north east to south west and 12m north east-south west. The area of the site is 0.03 ha. The site slopes steeply north west downwards from Belfield Lane to the partially developed houses. The rear gardens are primarily flat with an adjacent slope on the western site boundary that slopes steeply to the north west.

At the time of this investigation, the site was a partially developed plot of land with two partially constructed semi-detached houses present in the centre of the site.

To the north and west of the site are residential properties, to the east is Belfield Lane with wooded land beyond and to the south is a vacant plot of land with wooded lane and residential properties beyond.

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

Figure 1: Site Location Plan



Access was gained from Belfield Lane to the east of the site.

General site photographs are presented in Figure 2 below.

Figure 2: General Site Photographs

View of the site and partially constructed dwellings, looking north west



View of the proposed rear garden areas, looking north west



3.1 Proposed Development

It is understood that the Client intends to build two semi-detached residential properties on site with associated gardens and parking. Access will be provided via Belfield Lane.

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

Figure 3: Proposed Development Plan



4.0 SITE INVESTIGATION

4.1 Exploratory Fieldwork

The fieldwork was carried out by EEG on 7th July 2020 and comprised:

- Eight window sample boreholes (designated WS01 to WS07 inclusive) were each sunk to a depth of 0.70m 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.

Exploratory hole locations were selected prior to attending the site by an EEG engineer based on the proposed development layout 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.

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

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) 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).

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

A summary of exploratory holes undertaken during the investigation are presented in Table 1 below.

Table 1: Summary of Exploratory Holes Undertaken

Hole	Type*	Depth (m)	Date Started	Date Finished	Easting (m)	Northing (m)	Backfill Details**
WS01	WS	2.70	07/06/2020	07/06/2020	391234	413616	A
WS02	WS	4.00	07/06/2020	07/06/2020	391234	413608	A
WS03	WS	1.60	07/06/2020	07/06/2020	391233	413610	A
WS04	WS	1.50	07/06/2020	07/06/2020	391232	413612	A
WS05	WS	5.00	07/06/2020	07/06/2020	391238	413614	A
WS06	WS	0.70	07/06/2020	07/06/2020	391246	413602	A
WS06B	WS	6.00	07/06/2020	07/06/2020	391247	413602	A
WS07	WS	6.00	07/06/2020	07/06/2020	391254	413604	A
*WS = Window Sample Borehole **A=Arisings							

Figure 4: Exploratory Hole Location Plan



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 2 below.

Table 2: Summary of Laboratory Geotechnical Tests Undertaken

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

Chemical analyses were carried out on six 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 (SO_4), Sulphide, pH, Soil Organic Matter, Extractable Petroleum Hydrocarbons (EPH), Speciated Petroleum Hydrocarbon and Speciated Polyaromatic Hydrocarbons (PAH).

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

The sequence of strata encountered beneath the site was as follows:

- **Made Ground –** Variable Made Ground was encountered in all the exploratory holes, comprising:
  - Clayey sandy gravel (containing brick, concrete, timber, plastic, asphalt and sandstone). Frequent cobbles of brick, concrete and sandstone.
  - Organic sandy gravelly clay (containing brick, concrete, timber and sandstone).
  - Clay with occasional gravel (containing pockets of brick, timber and sandstone).

- **Clay** was encountered only in WS07 and only as a small amount at the end of the final sampling run, comprising:
  - Very stiff gravelly CLAY (containing gravel of mudstone and sandstone).

The depths of the various materials encountered in the exploratory holes are summarised in Table 3 below.

Table 3: Summary of Ground Conditions Encountered

Hole	Depth to Stratum (m bgl)		GROUNDWATER (m bgl)
	MADE GROUND	CLAY	
WS01	GL-2.70	-	-
WS02	GL-4.00	-	-
WS03	GL-1.60	-	-
WS04	GL-1.50	-	-
WS05	GL-5.00	-	-
WS06	GL-0.70	-	-
WS06B	GL-6.00	-	-
WS07	GL-5.80	5.80-6.00	-

5.2 Observable Indications of Contamination

A hydrocarbon odour was noted in the Made Ground clay from 3.00m to 4.00m.

With the exception of Made Ground gravels, visual/olfactory evidence of contamination was not encountered in any other of the exploratory holes during the fieldwork.

5.3 Obstructions

Cobbles of brick, concrete and sandstone impeded drilling in all exploratory holes and terminated drilling in WS01, WS02, WS03, WS05 and WS06.

WS04 was terminated at 1.50m due to the sampler bouncing on was most likely plastic or timber.

5.4 Groundwater

No groundwater was encountered in any of the boreholes or excavations carried out during the fieldwork.

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 4: 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)
WS2	1.50	MG	-	-	-	-	-	-	-	-	-	-	-	-	6.8	410
WS2	3.00	MG	-	-	-	-	-	-	-	-	-	-	-	-	6.8	440
WS6B	5.50	MG	-	-	-	-	-	-	-	-	-	-	-	-	6.9	400
WS7	5.80-6.00	Clay	14	35	12	23	-	9	40	37	14	-	-	-	7.0	370
*MG = Made Ground																

6.2 Made Ground

Variable Made Ground was encountered across the site to a maximum depth of 6.00m. Given the depth of the Made Ground, Standard Penetration Tests (SPT) were carried out in the material. Variable N values of 2 to 50 were recorded meaning the material varies from very loose/very soft to very dense/very stiff.

Sulphate content and pH value determination tests were carried out on nine samples of the Made Ground by the geotechnical and chemical laboratory. The **water-soluble sulphate** content of the samples ranged between 76 mg/l SO_4 to 440 mg/l SO_4 with **pH values** of 6.8 to 8.9.

6.3 Clay

An Atterberg Limit test has given a **liquid limit** value of 14% and a **plastic limit** value of 12%, resulting in a **plasticity index** value of 23%. These results suggest the samples tested are clay of low plasticity as shown on the Plasticity Chart(s) included in Appendix 2. For design purposes, a value of plasticity index = 23% is recommended.

Due to the depth of the Made Ground, only one SPT test was carried out in the clay, which resulted in an **SPT N value** of 36. The result suggests the clay is very stiff.

Shear strength may also be estimated from a correlation by Stroud and Butler(1975): for a clay with a plasticity index of 23%, c_u = 4.7 x SPT N value. Based on N values obtained, shear strength values in the range 169kN/m^2, suggesting the clay is very stiff.

Sulphate content and pH value determination tests were carried out on one sample of the Clay by the geotechnical laboratory. The **water-soluble sulphate** content of the sample was 370mg/l SO_4 with a **pH value** of 7.0.

7.0 GEOTECHNICAL ASSESSMENT

7.1 Proposed Development

It is understood that the Client intends to build two semi-detached residential properties on site with associated gardens and parking. Access will be provided via Belfield Lane. At the time of writing this report structural loadings were not known.

7.2 Ground Conditions Encountered

The exploratory holes encountered variable Made Ground (up to 6.00m thick) overlying stiff clay in WS07. Groundwater was not encountered during the fieldwork.

7.3 Foundation Considerations

Conventional shallow strip foundations are not considered suitable for the site, due to the presence of deep Made Ground.

Therefore, a piled foundation solution is recommended for this site and is discussed in the following section.

7.3.1 *Piled Foundations*

For the ground conditions at this site, 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 due to the proximity and sensitivity of the neighbouring properties. It should also be noted that driven piles can also potentially create preferential pollutant pathways.

Given the proximity of neighbouring structures, 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 any 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.

Floor slabs should be designed as suspended if the piled solution is used.

7.4 Pavement Design

Based on the ground conditions encountered it is recommended a conservative design CBR of 1% is used for near surface Made Ground materials.

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.

Table 5: 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.								

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.

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 Made Ground 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.

Granular Made Ground 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.

7.8 Drainage

Based on the ground and groundwater conditions encountered, soakaway drainage is unlikely to be suitable at this site.

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

Contaminant	Typical Values* for:					Test Results	Class
	Uncontaminated Soils	Slight Contamination	Contaminated	Heavy Contamination	Unusually Heavy Contamination		
	Class A	Class B	Class C	Class D	Class E		
pH (alkaline)	7 - 8	8 - 9	9 - 10	10 - 12	12	7.8 - 8.9	A - B
Arsenic	0 - 30	30 - 50	50 - 100	100 - 500	500	4 - 46	A - B
Cadmium	0 - 1	1 - 3	3 - 10	10 - 50	50	0.8 -2.1	A - B
Chromium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	13 - 33	A
Copper	0 - 100	100 - 200	200 - 500	500 - 2500	2500	14 - 78	A
Lead	0 - 500	500 - 1000	1000 - 2000	2000 – 1%	1.0%	81 - 221	A
Mercury	0 - 1	1 - 3	3 - 10	10 - 50	50	< 1	A
Nickel	0 - 20	20 - 50	50 - 200	200 - 1000	1000	11 - 23	A - B
Zinc	0 - 250	250 - 500	500 - 1000	1000 - 5000	5000	56 - 296	A - B
Boron	0 - 2	2 - 5	5 - 50	50 - 250	250	< 1	A
Selenium	0 - 1	1 - 3	3 - 10	10 - 50	50	< 3	A
Barium	0-500	500-1000	1000-2000	2000-1.0%	1.0%	123 - 217	A
Beryllium	0 - 5	5 - 10	10 - 20	20 - 50	50	< 0.5 – 0.9	A
Vanadium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	11 - 23	A
Sulphate	0 - 2000	2000 - 5000	5000 – 1%	1% - 5%	5.05%	647 - 1506	A
Sulphide	0 - 10	10 - 20	20 - 100	100 - 500	500	< 5	A
Cyanide (free)	0 - 1	1 - 5	5 - 50	50 - 100	100	< 2	A
Phenol	0 - 2	2 - 5	5 - 50	50 - 250	250	< 2	A

Based on the above results it is considered there is a low potential risk from soil contamination to construction workers, ground workers and members of the public during construction. Appropriate measures, such as PPE, site health plans, and appropriate disposal of material arisings will be required to mitigate any risk.

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

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

- Defra C4SL Health Criteria Values (March 2014), where available; and
- Tier 1 assessment values - based on LQM/CIEH Suitable 4 Use Levels(2015) (S4ULs).

The soil chemical testing results are summarised in Table 7 overleaf.

Table 7: Soil Results Comparison with C4SL/S4UL Values

Determinand	C4SL/S4UL Levels Residential (mg/kg)	WS01 0.50m MG	WS01 1.00m MG	WS02 0.30m MG	WS05 0.70m MG	WS06B 0.40m MG	WS07 0.60m MG	No of Exceedances
Metals								
Arsenic	37	35	**40**	29	**46**	11	4	2
Beryllium	1.7	0.9	0.9	0.8	0.8	0.7	< 0.5	0
Boron	290	< 1	< 1	< 1	< 1	< 1	< 1	0
Cadmium	22	1.8	2.1	1.6	2	1.1	0.8	0
Chromium	910	32	31	29	33	18	13	0
Chromium VI	21	< 2	< 2	< 2	< 2	< 2	< 2	0
Copper	2400	78	75	65	62	32	14	0
Lead	200	**221**	**203**	198	165	159	81	2
Mercury	1.2	< 1	< 1	< 1	< 1	< 1	< 1	0
Nickel	180	23	23	19	20	15	11	0
Selenium	250	< 3	< 3	< 3	< 3	< 3	< 3	0
Vanadium	410	23	22	20	19	19	11	0
Zinc	3700	296	276	259	259	112	56	0
Petroleum Hydrocarbons								
Benzene	0.087	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
Toluene	130	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0
Ethylbenzene	47	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
o-xylenes	60	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
m-xylenes	59	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
p-xylenes	56	< 0.002	< 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	< 0.01	0
Aliphatic EC >6-8	100	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0
Aliphatic EC >8-10	27	2	< 2	< 2	< 2	< 2	2	0
Aliphatic EC >10-12	130 (v)	< 2	< 2	< 2	< 2	< 2	< 2	0
Aliphatic EC >12-16	1100 (s)	< 3	< 3	< 3	< 3	< 3	< 3	0
Aliphatic EC >16-21	65000 (s)	< 3	< 3	< 3	< 3	< 3	< 3	0
Aliphatic EC >21-35	65000 (s)	< 10	< 10	< 10	< 10	< 10	< 10	0
Aromatic EC >5-7	70	< 0.01	< 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	< 0.05	0
Aromatic EC >8-10	34	< 2	< 2	< 2	< 2	< 2	< 2	0
Aromatic EC >10-12	74	< 2	< 2	< 2	< 2	< 2	< 2	0
Aromatic EC >12-16	140	9	6	8	6	4	9	0
Aromatic EC >16-21	260	27	17	19	25	18	27	0
Aromatic EC >21-35	1100	39	28	< 10	15	< 10	39	0
Polycyclic Aromatic Hydrocarbons								
Naphthalene	2.3	0.95	0.63	0.5	0.29	0.66	0.95	0
Acenaphthylene	210	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Acenaphthene	170	1.3	0.2	0.33	0.39	0.46	1.3	0
Fluorene	170	1.06	0.19	0.35	0.36	0.44	1.06	0
Phenanthrene	95	7.1	2.33	2.96	4.47	5.3	7.1	0
Anthracene	2400	1.55	0.46	0.56	0.77	0.91	1.55	0
Fluoranthene	280	5.79	2.68	3.29	4.7	4.28	5.79	0
Pyrene	620	5.07	2.56	3.02	4.19	3.72	5.07	0
Benzo(a)anthracene	7.2	2.06	1.2	1.32	1.75	1.15	2.06	0
Chrysene	15	2.03	1.34	1.43	2.02	1.34	2.03	0
Benzo(a)pyrene	5	1.45	0.92	0.92	1.19	0.57	1.45	0
Benzo(b)fluoranthene	2.6	2.1	1.12	1.25	1.68	0.85	2.1	0
Benzo(k)fluoranthene	77	0.77	0.42	0.57	0.53	0.37	0.77	0
Indeno(1,2,3-cd)pyrene	27	0.6	0.42	0.38	0.52	0.23	0.6	0
Dibenz(a,h)anthracene	0.24	0.13	< 0.1	0.14	0.2	< 0.1	0.13	0
Benzo(ghi)perylene	320	0.51	0.37	0.35	0.5	0.21	0.51	0
Phenols								
Phenol	280	< 2	< 2	< 2	< 2	< 2	< 2	0
Concentrations in **red** are above the assessment criteria based on Residential End Use with Plant Uptake. MG = Made Ground								

Elevated concentrations of contaminants of concern, with respect to the long-term protection of human health, have been identified in three samples at two locations across the site when compared to residential end use (with plant uptake) assessment criteria. The contaminants identified are presented as Table 8 below.

Asbestos fibres were detected in five samples at four locations across the site. The details of the asbestos contamination can be seen in the table below.

Table 8: Summary of Contamination

Contaminant	Location
Arsenic	WS01 (1.00m) & WS05 (0.70m)
Lead	WS01 (0.50m & 1.00m)
Asbestos	WS01 (0.50m) – Bundle of chrysotile fibres – 0.003% WS01 (1.00m) – Bundles of chrysotile & amosite fibres – 0.002% WS02 (0.30m) – Bundle of chrysotile fibres – < 0.001% WS05 (0.70m) – Bundles of chrysotile & amosite fibres – 0.003% WS06B (0.40m) – Bundle of chrysotile fibres – 0.001%

8.3 Soil Waste Assessment

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

The results are summarised in Table 9 below and presented in full in Appendix 4.

Table 9: Waste Classification of Soils

Location	Depth (m bgl)	WM3.1 Classification	Comments
WS01	0.50	Non-Hazardous	-
WS01	1.00	Non-Hazardous	-
WS02	0.30	Non-Hazardous	-
WS05	0.70	Non-Hazardous	
WS06B	0.40	Non-Hazardous	
WS07	0.60	Non-Hazardous	-

9.0 CONCLUSIONS & RECOMMENDATIONS

9.1 Soil Contamination

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

Based on the results of the chemical testing, exceedances in chemical contaminants were observed in three samples at two locations across the site. The contaminants included arsenic and lead which pose a moderate risk to future residential end users. In order to break potential pollutant linkages to future residential end users, it is recommended that landscaped areas in should be capped with clean cover soils.

The presence of higher levels of contamination on areas of the site not covered by the current exploratory holes should not be discounted and additional spot checks would be prudent, particularly during groundworks. This testing can be carried out as part of the Soil Management Plan for the site.

9.2 Foundations

Foundations should be placed within the natural clay horizon beneath the Made Ground. Due to the thickness of the Made Ground, a piled foundation solution will most likely need to be adopted.

Due to the thickness of made ground suspended ground floor slabs should be utilised.

For concrete placed in the Made Ground the Design Sulphate Class for the site, should be taken as DS-1, and the Aggressive Chemical Environment for Concrete (ACEC) site classification be taken as AC-1s.

9.3 Asbestos

Asbestos was detected in five of the samples tested during this investigation. The asbestos is reported as being present as bundles of chrysotile and amosite and was present in WS01, WS02, WS05 and WS0 6B. Quantification of the asbestos revealed that the samples contained between less than 0.001% to 0.003% asbestos.

Considering the proposed residential end use with rear garden areas, the risk posed to end users from asbestos is concluded to be **MODERATE** to **LOW.**

The risk to groundworkers from asbestos is concluded to be **MODERATE** to **LOW** with a **MODERATE** to **LOW** risk to adjacent land users (due to the potential generation of airborne fibre).

As a minimum the follow precautions will be required to minimise the risk to construction workers and adjacent land users:

- Communicate the risk to site personnel at the induction stage;
- Ensure all site personnel have suitable training and PPE/RPE;

- Ensure soils do not dry out and become dusty.

9.4 Soil Disposal

Soils should be disposed of at a suitable site, registered to take the levels of contamination encountered. The soils collected from all borehole locations have been classified as Non-Hazardous (See Table 9) for the purpose of off-site disposal in accordance with Environment Agency guidance WM3.1.

9.5 Risk to Buried (Water) Services

It is considered that, due to the presence of contamination, non-standard materials may be required for new water pipes. Further advice should be sought from the local water company.

Previous guidance on buried water pipes was contained in Water Regulations Advisory Scheme (WRAS) Guidance Note No. 9-04-03(2002), however this has been superseded by the UK Water Industry Research Report 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites' Ref 10/WM/03/21 (January 2011).

9.6 Site Personnel

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

9.7 Other Matters

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

APPENDIX 1

EXPLORATORY HOLE LOGS

APPENDIX 2

GEOTECHNICAL TESTING RESULTS

APPENDIX 3

CHEMICAL TESTING RESULTS

APPENDIX 4

SOIL WASTE ASSESSMENT

APPENDIX 5

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 2020 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.