



CCG-C-21-12359

**PHASE II GEOENVIRONMENTAL REPORT
FOR SITE AT**

**163 GREAT DUCIE STREET,
MANCHESTER**

JULY 2021



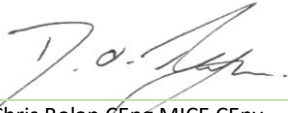
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1.0 INTRODUCTION

1.1 Background & Nature of Development

CC GEOTECHNICAL LIMITED (CCG) is providing consultancy services to services to **SEED Architects (The Client)** in connection with the proposed redevelopment of land at 163 Great Ducie Street, Cheetham Hill, Manchester, M3 1FF.

It is understood that the site is to be redeveloped for commercial use by the construction of a 2-storey building adjoining the existing commercial building, to be constructed in traditional brick elevations, together with a hard paved access road and car parking bays. The existing and proposed site layouts, together with elevations for the scheme are as shown on **SEED ARCHITECTS** architectural drawings contained herein.

The proposed development falls within the administrative jurisdiction of **MANCHESTER CITY COUNCIL**.

2.0 PREVIOUS STUDIES

The development site was the subject of a Phase I Desk Study Report prepared by **CCG** under report reference No. **CCG-C-21-12309**, dated April 2021, which concluded that a Phase II intrusive investigation was required, and made recommendations on the scope of the Phase II investigation.

This report documents the findings of the Phase II investigation.

This report should be read in conjunction with **CCG** Desk Study Report No. **CCG-C-21-12309**, and with the Notes on Limitations, given in Appendix I.

3.0 PURPOSE & AIMS OF THE PHASE II INTRUSIVE INVESTIGATION

The primary purpose of the Phase II intrusive investigation was to confirm the indications of the desk study with particular respect to:

- The assessment of the nature and extent of contamination in relation to potential risks to human health for end users and construction workers
- The assessment of the nature and extent of contamination in relation to potential risks to the fabric of buildings and services
- The refinement of the Preliminary Conceptual Model confirming if any pollution linkages have been demonstrated to be present on site
- The identification of feasible remediation measures to remove or break any identified pollution linkages

4.0 SITE DATA

4.1 Site Description

A detailed description of the site location and its immediate environs are discussed in the above referenced desk study report, and some of the principal observations are summarised hereunder.

The study site comprises a rectangular shaped parcel of land located immediately to the south of 163 Great Ducie Street, Cheetham Hill, Manchester, M3 1FF, as shown on Site Location Plan (Drawing No. 12359-1) and Aerial Site Boundary Plan (Drawing No: 12309-2), both contained within Appendix A. The **ORDNANCE SURVEY** coordinates for the approximate site centre are 383602E, 399449N.

The site is situated within a commercial context and comprises a regular shaped parcel of land which extends to the approximate dimensions of c.55m x 30m, its longer axis being on a northwest-southeast alignment. It is bound to the west by

private car parking. To the east and south by public pavements extending along Great Ducie Street and Langston Street respectively, and commercial properties to the north.

At the time of undertaking the above referenced site walkover survey, there was no visual evidence of the presence of non-native plant species within or adjoining the site boundaries.

Site access / egress is via either the car park off Langston Street or Great Ducie Street frontage.

4.2 Published Geology

The geology of the site was researched by reference to the *British Geological Survey (BGS) 1:50, 000 Scale (Bedrock Edition) Sheet 085 Manchester (2010)* and Ambrose. K et.al (2014) '*Lithostratigraphy of the Sherwood Sandstone Group of England, Wales and south-west Scotland*'. His Majesties Stationary Office, London.

The **BGS 1:10, 000 Scale Drift Geological map** indicate that the study site is underlain by natural drift deposits comprising Alluvium - comprising gravel sand silt and clay deposits of fluvial origin (*Holocene Epoch - Late Quaternary*).

The solid geology is documented to comprise the Chester Sandstone Formation of the Sherwood Sandstone Group comprising conglomerates and reddish brown, cross-bedded, pebbly sandstones with subordinate beds of red-brown mudstone. The conglomerates have a reddish-brown sandy matrix and consist mainly of pebbles of brown or purple quartzite, with quartz conglomerate and vein quartz (*Early Triassic Epoch - Olenekian Sub-Age*). Previously known as Chester Pebble Beds.

The general dip of the solid geology within the surrounding area is not documented on the **BGS** solid mapping data. There are 2nr documented geological lines of weakness (i.e. faults) within 500m of the study site. 77m and 423m north-east. The 'Indicative Atlas of Radon in England and Wales' (Miles. J.C.H et.al, 2007) Map 17 'Lancashire, south Cumbria and western North Yorkshire' shows the site to be situated within an area where it is believed that less than 1% of the properties within the area are affected by Radon and therefore no Radon Protection Measures will be required for new structures in contact with the ground.

As with many previously developed sites superficial made ground deposits of an unknown composition thickness and extent associated with the development of the site and its immediate environs may underlie the site.

4.3 Hydrogeology & Hydrology

Information pertaining to hydrogeological and hydrological features of the site may be summarised as follows:

- The solid geology (Chester Sandstone Formation) is classified as being a Principal Aquifer
- The drift geology (Alluvium) is classified as being a Secondary A Aquifer
- There are no documented water courses within 75m of the study site
- There are no records pertaining to Potable Water Abstraction Licences within 300m of the site
- There are no records pertaining to Ground Water Abstraction Licences within 300m of the site
- There are no records pertaining to Surface Water Abstraction Licences within 1km of the site
- The site is located within a Zone III Source Protection Zone (Total Catchment)
- The site is located within an Environment Agency Zone II and/or III Flood Plain

5.0 PHASE I FINDINGS AND CONCLUSIONS

The Phase I Desk Study (CCG-C-21-12309) carried out by **CCG**, provided the following conclusions in relation to contamination:

- A potential risk of contamination cannot be discounted based on the current and past uses of the site

- The site was categorised as “MODERATE” liability risk associated with soil contamination
- The site was categorised as “MODERATE / LOW” liability risk associated with ground gas contamination

The foregoing report identified a significant number of potential risks, and if present, these could adversely impact on human or environmental receptors. Given the sensitivity of the proposed end use, and since no previous site investigation has been undertaken, an intrusive phase of investigation was undertaken to determine whether the potential pollutant linkages were present on site.

6.0 FIELDWORK

6.1 Introduction

Based on the findings of the Phase I Report, a programme of fieldwork investigation was undertaken in May 2021. The programme comprised:

- The manual excavation and CAT scanning of 4nr borehole service avoidance pits, each extending to 1.2mbngl
- The subsampling of borehole starter pit arisings for soil contamination analyses
- The sinking of 4nr boreholes (WS1 – WS4) from the base of each borehole starter pit using light dynamic sampling methods
- Installation of 50mm HDPE plain and slotted well-tube and associated headworks, complete with non-lime pea gravel surround and bentonite seals at 3nr borehole positions (WS1 – WS3)
- The instigation of a programme of gas monitoring comprising 6nr rounds over a month period

The fieldwork was planned in accordance with BSEN 1997-1 (2007) Eurocode 7, BS10175: 2011, BS5930: 2015, and the sampling and monitoring methodologies employed by **CCG** as presented in Appendix B, insofar as they related to the scope of the investigation.

The layout of the investigation borehole and gas / groundwater monitoring standpipe locations are as annotated on **CCG** Drawing No. 12359-2 presented in Appendix A.

6.2 Borehole Drilling & Monitoring Installations

6.2.1 Light Dynamic Sampling Boreholes

A total of 4nr boreholes (WS1 – WS4) were sunk using light dynamic sampling methods using a Dando Terrier 2000 rig deploying 100mm casings and associated tools.

Each borehole location was positioned clear of all overhead services and scanned using CAT cable avoidance scanner before and during hand excavation of a starter pit extending to 1.2mbgl.

Boring tools were decontaminated prior to commencement.

In this method of investigation samples of subsoils are recovered by driving and extracting a series of reducing diameter 1m long steel tubes. Standard penetration test's (SPT's) were undertaken at regular depth increments, with hand shear vane (HSV) testing being undertaken in cohesive strata. This method of sampling recovers relatively “undisturbed” soil profiles in Perspex tubes, which are used to line the steel tubes. The Perspex tubes were split and carefully logged and subsampled. Subsamples for potential chemical analysis were removed at appropriate positions from the profile and transferred to chilled amber glass jars and vials for laboratory analysis.

The logs of the boreholes, annotated with sampling details, SPT ‘N’ and HSV (Cu-kN/m²) values and details of standpipe construction are given in Appendix B.

6.2.2 Monitoring Installations

Standpipes comprising 50mm diameter HDPE plain and slotted well tube set in bentonite and non-limestone pea gravel surround were installed at 3nr borehole positions. Each standpipe was fitted with a gas valve connector and was protected by a flush cover set in concrete. Details of standpipe installations are provided on the relevant borehole logs in Appendix B and summarised in the tabulation hereunder:

Table 1: Borehole Installation Details

BOREHOLE	DEPTH OF BOREHOLE (mbgl)	DEPTH OF STANDPIPE [mbgl]	RESPONSE ZONE (mbgl)	
			FROM	TO
WS1	3.0m	2.8m	1.0m	2.8m
WS2	3.0m	2.8m	1.0m	2.8m
WS3	3.0m	2.8m	1.0m	2.8m

The standpipe installations were periodically monitored for flow rate and composition of ground gas using a Geotechnical Instruments GA 2000 infra-red analyser. The installations were also monitored for standing water levels with an electronic dip meter.

The results of the gas and groundwater monitoring, together with calibration certificates of the instruments used are given in Appendix C.

7.0 OBSERVED STRATIGRAPHY

The stratigraphy of the boreholes was generally consistent with the documented geology. The succession may be generalised as tabulated hereunder:

Table 2: Observed Stratigraphy

Location	STRATIGRAPHY
WS1	Black silty very sandy GRAVEL. Gravel is fine to coarse subangular to subrounded limestone capping layer to 0.2mbgl, underlain by dark brown silty very gravelly SAND, with a medium cobble content. Gravel is fine to medium angular to subangular brick and sandstone (MADE GROUND) to 2.8mbgl.
WS2	
WS3	
WS4	The borehole refused and terminated on reddish brown weathered sandstone which was proven to 3.0mbgl. Black silty very sandy GRAVEL. Gravel is fine to coarse subangular to subrounded limestone capping layer to 0.2mbgl, underlain by dark brown silty very gravelly SAND, with a medium cobble content. Gravel is fine to medium angular to subangular brick and sandstone (MADE GROUND) to 1.2mbgl. The sequence continued in natural firm brown slightly sandy slightly gravelly silty CLAY to 1.7mbgl, underlain by dense brown very sandy silty GRAVEL. Gravel is fine to coarse subrounded to subangular sandstone proven to 2.8mbgl The borehole refused and terminated on reddish brown weathered sandstone which was proven to 3.0mbgl.

There was no visual and/or olfactory evidence of contamination and/or biodegradable materials affecting the made ground mass at any sampling position.

8.0 GROUNDWATER REGIME

All borehole positions were reported to be dry on completion of fieldworks and during the ongoing gas – groundwater monitoring programme.

9.0 **LABORATORY TESTING**

9.1 **Soil Engineering Testing**

A programme of soil engineering testing was undertaken at a UKAS / MCERTS accredited laboratory associated with **CCG**. The programme comprised:

- Determination of soil moisture content in accordance with BS: 1377: Part 2: 1990
- Determination of Atterberg Limits in accordance with BS: 1377: Part 2: 1990
- Determination of Particle Size Distribution in accordance with BS 1377-2:1990

The soil engineering test results are presented in Appendix D.

9.2 **Contamination Analyses**

A programme of soil chemical analyses was undertaken at a UKAS / MCERTS accredited laboratory:

- 4nr subsamples of made ground soils were analysed to a broad range of contaminants including metals, non-metals, speciated PAH's
- 4nr subsamples of made ground soils were analysed for hydrocarbons to the TPHCWG methodology
- 4nr subsamples of made ground soils were analysed for BTEX compounds
- 4nr subsamples of made ground soils were screened for asbestos contaminants

The soil contamination test results and certificates are presented in Appendix E.

10.0 **ASSESSMENT OF RISKS TO THE BUILT ENVIRONMENT**

10.1 **Specification of Buried Concrete**

The data obtained in the investigations was assessed against the guidance given in BRE Special Digest 1: 2005, as summarised hereunder:

Table 3: Design Chemical Class Based on Soil Data

CONCRETE SPECIFICATION DATA SHEET		
Is the site Brownfield or Greenfield?	Brownfield	
Is the water table static or mobile?	Mobile	
Highest water-soluble Sulphate results	70mg/l	Design Sulphate Class of DS-1 Class of AC-1
Lowest pH result	8.1	
Intended Working Life	50 years	Adopt Design Chemical Classification of DC-1

On the basis of the foregoing assessments, concrete in the ground should be specified to conform to the compositional requirements of Design Chemical Class **DC 1**, as defined in BRE Special Digest 1: 2005.

10.2 **New Water Mains Supply**

The assessment of requirements for new water mains within the investigation area was based on the criteria specified in Paper 10/WM/03/21 'Guidance for the selection of Water Supply Pipes to be used in Brownfield Sites' published by UK Water Industry Research (UKWIR) January 2011, and the supplementary guidance UUENG/RL/V2/September 2012, published by United Utilities Water (UWU).

The findings indicate that hydrocarbon concentrations in soils are above the threshold concentrations of the UKWIR and UWU guidance, and therefore new water mains should be specified as PE/AL/PE barrier (Protectaline) pipe construction. Also, the new water mains should be laid in a clean remediated alignment, with 300mm clean gravel surround (i.e 600mm trench, with mains set centrally).

Pipes should be laid in accordance with BS EN 12201-2 'Plastic piping systems for water supply, and for drainage and sewerage under pressure as stated in UKWIR guidance.

Notwithstanding the above preliminary assessment, the developer should contact the relevant water supply company (United Utilities) to obtain concurrence with the recommendations given above and may be required to return a completed UUW Risk Assessment.

10.3 Assessment of Risk from Ground Gases

Standpipes were constructed such that response zones were within the permeable made ground strata. Using the data gathered in the monitoring programme, a gas risk assessment was undertaken in accordance with the ground gas risk assessment methodology (See Appendix H) employed by **CCG**. The ground gas risk assessment methodology conforms to current UK guidance on the assessment of risks posed by ground gases.

The potential sources of gas identified in the desk study were generally considered as sources of "Low" generation potential, and of a "Low" sensitivity for a commercial unit, a programme of monitoring comprising of 4 rounds distributed over a month period was adopted.

A gas risk assessment was undertaken in accordance with current UK guidelines set out in CIRCA C665 2007 "Assessing Risk Posed by Hazardous Gases to Buildings". The CIRIA risk assessment methodology uses typical maximum soil gas concentrations and worse case borehole flow rates to define a "Characteristic Situation" for the shallow gas regime.

The volumetric gas flow rate used by the risk assessment is termed "Gas Screening Value (GSV)" in the guidance and is defined below.

Table 4: Gas Monitoring Data

Position	WS1	WS2	WS3
No Monitoring Visits	4	4	4
Maximum CH ₄ (%)	Nil	Nil	Nil
Maximum CO ₂ (%)	1.4	0.3	Nil
Lowest O ₂ (%)	13.1	19.9	20.2
Maximum H ₂ S (ppm)	Nil	Nil	Nil
Maximum CO (ppm)	Nil	Nil	Nil
Peak Flow (l/hr)	<0.1	<0.1	<0.1
Water Level ranges (m)	Dry	Dry	Dry
PID response	0.0	0.0	0.0
Pressure Range (mb)	1012-1019mb		

After 4nr rounds of monitoring, a Gas Screening Value (GSV) of 0.0014l/hrs is calculated for CO₂.

A preliminary maximum Gas Screening Value (GSV) of 0.0014l/hrs is calculated for CO₂. Using this GSV value, the risk to the proposed development was assessed in line with Situation A as defined in CIRIA C665, and on this basis the site complies with Characteristic Situation (CS) 1. Under CS1, gas protective measures are not required.

11.0 HUMAN HEALTH RISK ASSESSMENT

11.1 Generic Quantitative Risk Assessment (Tier 2 / GQRA)

An assessment of the soil analysis data was carried out in accordance with the guidance presented in CLR11 and in accordance with current guidance and legislation.

The Human Health Risk Assessment was carried out in accordance with the **CCG** methodology for assessing soil contamination data as contained in Appendix H, and since it is proposed that the site be redeveloped for Industrial use, the assessment was based on criteria contained in publication LQM/CIEH S4UL's for Human Health Risk Assessment (2015) (CCG licence S4UL3233), applicable to the "Commercial/Industrial" land use scenario. This document does not provide criteria for Lead, for which the results were compared to the C4SL published by DEFRA SP1010 Development of Category 4 Screening Levels.

11.2 Assessment of Contamination Data

Based on a Soil Organic Matter content of an average 1%, an assessment of the soil data was undertaken as summarised in the tabulations hereunder, and presented on the worksheets in Appendix F.

11.2.1 Assessment of Metal Data

The assessment of the metal data is presented hereunder:

Table 5: Assessment of Metal Data

Contaminant	LQM / CIEH S4UL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Cadmium	190	1.5	-	-
Chromium	8600	40.7	-	-
Copper	68000	57.7	-	-
Lead	2300	342	-	-
Mercury	58	0.7	-	-
Nickel	980	44.1	-	-
Zinc	730000	285	-	-

The above assessment confirms that no soil contaminant exceeds its respective residential land use soil guideline criteria and therefore no risk to human health is indicated.

11.2.2 Assessment of Non-Metal Data

The assessment of the non-metal data is presented hereunder:

Table 6: Assessment of Non-Metal Data

Contaminant	LQM / CIEH S4UL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Arsenic	640	13.4	-	-
Selenium	12000	<1	-	-
Free Cyanide	120	<1	-	-

The above assessment concludes that no contaminant exceeds its respective associated guideline criterion and hence no risk to human health is indicated.

11.2.3 Assessment of PAH Data

The assessment of the non-metal data is presented hereunder:

Table 7: Assessment of PAH Data

Contaminant	LQM / CIEH S4UL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Naphthalene	460	0.1	-	-
Acenaphthylene	97000	0.1	-	-
Acenaphthene	97000	0.5	-	-
Fluorene	68000	0.3	-	-
Phenanthrene	22000	2.5	-	-
Anthracene	540000	0.7	-	-
Fluoranthene	23000	4.6	-	-
Pyrene	54000	4.4	-	-

Table 7: Assessment of PAH Data (continued)

Contaminant	LQM / CIEH S4UL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Benz(a)anthracene	170	2.6	-	-
Chrysene	350	4.1	-	-
Benzo(b)fluoranthene	44	3.6	-	-
Benzo(k)fluoranthene	1200	3.6	-	-
Benzo(a)pyrene	35	3.5	-	-
Indeno(123-cd)pyrene	510	3.8	-	-
Dibenz(ah)anthracene	3.6	1.5	-	-
Benzo(ghi)perylene	4000	4.6	-	-

The above assessment concludes that no contaminant exceeds its respective associated guideline criterion and hence no risk to human health is indicated.

11.2.4 Assessment of Petroleum Hydrocarbon Data

The assessment of the Petroleum Hydrocarbon (TPH) data is presented hereunder:

Table 8: Assessment of Hydrocarbon Data

Contaminant	LQM / CIEH S4UL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Aromatic EC5-EC7	46000	<0.01	-	-
Aromatic EC7-EC8	110000	<0.01	-	-
Aromatic EC8-EC10	8100	<1.0	-	-
Aromatic EC10-EC12	28000	<1.0	-	-
Aromatic EC12-EC16	37000	<1.0	-	-
Aromatic EC16-EC21	28000	15.4	-	-
Aromatic EC21-EC35	28000	876	-	-
Aliphatic EC5-EC6	5900	<0.01	-	-
Aliphatic EC6-EC8	17000	<0.01	-	-
Aliphatic EC8-EC10	4800	3.2	-	-
Aliphatic EC10-EC12	23000	5.8	-	-
Aliphatic EC12-EC16	82000	26.3	-	-
Aliphatic EC16-EC35	1700000	2079	-	-

The above assessment concludes that no contaminant exceeds its respective associated guideline criterion and hence no risk to human health is indicated.

11.2.5 Assessment of Asbestos Data

Asbestos containing materials (ACM's) were not detected in any soil analysed and therefore no risk to human health is indicated.

11.2.6 Assessment of BTEX Data

The appended laboratory contamination results confirm that all BTEX compounds are below their limit of detection (LOD) and therefore no risk to human health is indicated.

11.2.7 Summary of Human Health Assessment

The above assessment confirms all soils to be below their respective soil guideline criteria and therefore no risk to human health is indicated.

12.0 POST INVESTIGATION CONCEPTUAL MODEL

Based on the findings of the investigation, a post investigation conceptual model may be constructed illustrating proven pollution linkages and summarising the conceptual remediation recommendations discussed above, as tabulated hereunder.

Table 9: Post Investigation Conceptual Model

Source	Pathway	Receptor	Remedial Options
No soil contaminant exceeds its respective soil guideline criteria.	N/A	N/A	No pre / post construction remedial works required.
Organic contaminants in soils – Total Petroleum Hydrocarbon fractions	Direct Migration	Occupant / Employee	The findings indicate that the soil concentrations are above the threshold concentrations of the UKWIR and UUW guidance, and therefore new water mains should be specified as PE/AL/PE barrier (Protectaline) pipe construction. Also, the new water mains should be laid in a clean remediated alignment, with 300mm clean gravel surround (i.e 600mm trench, with mains set centrally). Pipes should be laid in accordance with BS EN 12201-2 'Plastic piping systems for water supply, and for drainage and sewerage under pressure as stated in UKWIR guidance. Notwithstanding the above preliminary assessment, the developer should contact the relevant water supply company (United Utilities) to obtain concurrence with the recommendations given above and may be required to return a completed UUW Risk Assessment.

13.0 **GEOTECHNICAL ASSESSMENT**

13.1 **Introduction**

It is understood that the site is to be redeveloped for commercial use by the construction of a 2-storey building adjoining the existing commercial building, to be constructed in traditional brick elevations, together with a hard paved access road and car parking bays. The existing and proposed site layouts, together with elevations for the scheme are as shown on **SEED Architects** architectural drawings contained herein.

13.2 **Observed Ground Conditions**

This ground investigation confirms the ground in the vicinity of the build to be uniform and comprises of a thin veneer of gravel (0.20m thick) overlying a granular MADE GROUND comprising dark brown silty very gravelly sand, with medium cobble content to around 2.80mbgl before terminating on weathered SANDSTONE proven to 3.0mbgl.

All borehole positions were reported to be dry on completion of fieldworks.

There was no visual and/or olfactory evidence of contamination and/or biodegradable materials affecting the made ground mass at any sampling position.

13.3 **Foundation & Floor Slab Recommendations**

Taking account of the observed ground conditions, traditional strip (spread) foundations are not considered a suitable option due to the presence and thickness of the made ground. Ground improvement by vibro displacement methods is unlikely to be feasible in such close proximity to existing properties. It is therefore recommended that a piled foundation solution be adopted.

Thick wall steel tubular piles is the preferred pile type since these will key into the underlying sandstone providing stability to the pile. cased bottom driven cast in-situ displacement piles be the adopted pile solution with piles being driven to 'set' calculated to conform to the engineer's specified loadings.

the purposes of preliminary design, the structural carrying capacity of bottom driven piles may be taken as:

Table 10: Pile Carrying Capacity

Pile Diameter (mm)	Carrying Capacity (kN)
140	300
178	500

The indication of the borehole logs is that piles are likely to extend to around 3.5mbgl for loadings as above.

Piling contractors must be required to provide dynamic installation calculations for the actual loadings calculated to be imposed on each pile, and to provide pile installation records.

A cast insitu suspended or precast suspended floor slab is recommended.

13.5 Excavations

Excavations in the observed made ground and natural drift soils may be undertaken by light hydraulic excavators. Excavations in excess of 1.2mbgl in poorly consolidated soils will require side support.

13.6 Groundwater Management

All borehole positions were reported to be dry on completion of fieldworks and during the ongoing gas – groundwater monitoring programme. Notwithstanding this assessment, a prudent contractor would allow for some minor pumping to maintain dry working conditions during periods of heavy / prolonged periods of precipitation.

14.0 SUMMARY CONCLUSIONS

The recommendations hereunder are based on the salient sections of the report and should not be referred to in isolation of the relevant sections of the report. All recommendations are subject to Regulatory Authority review.

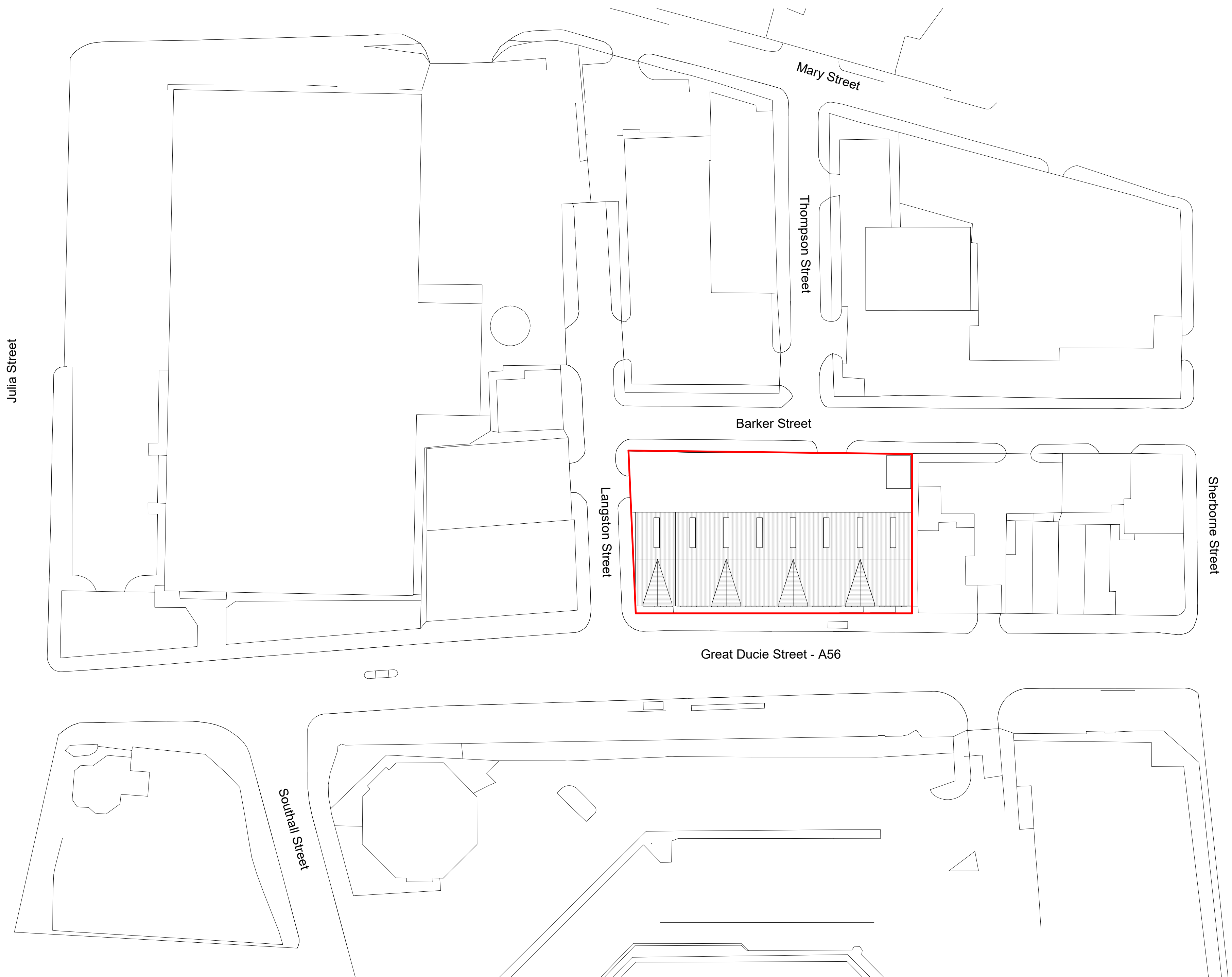
Table 11: Summary of Conclusions

Soil Contamination & Remediation	No soil contaminant exceeds its respective soil guideline criterion for commercial land use; hence no post remedial works are required. Notwithstanding the above human health risk assessment, it is recommended that any new areas of proposed landscaping receive as a minimum 300mm of clean imported topsoil to promote plant establishment
Water Mains	The findings indicate that the soil concentrations are above the threshold concentrations of the UKWIR and UUW guidance, and therefore new water mains should be specified as PE/AL/PE barrier (Protectaline) pipe construction. Also, the new water mains should be laid in a clean remediated alignment, with 300mm clean gravel surround (i.e 600mm trench, with mains set centrally). Pipes should be laid in accordance with BS EN 12201-2 'Plastic piping systems for water supply, and for drainage and sewerage under pressure as stated in UKWIR guidance. Notwithstanding the above preliminary assessment, the developer should contact the relevant water supply company (United Utilities) to obtain concurrence with the recommendations given above and may be required to return a completed UUW Risk Assessment.
Concrete specification	Concrete in the ground should be specified to conform to the compositional requirements of DC-1 as defined in BRE Special Digest 1: 2005
Gas Risk Assessment	A preliminary maximum Gas Screening Value (GSV) of 0.0014l/hrs is calculated for CO ₂ . Using this GSV value, the risk to the proposed development was assessed in line with Situation A as defined in CIRIA C665, and on this basis the site complies with Characteristic Situation (CS) 1. Under CS1, gas protective measures are not required.
Foundation Design	See Section 13.0 for fuller discussion
Floor Slabs	See Section 13.0 for fuller discussion
Groundwater Control	All borehole positions were reported to be dry. Notwithstanding this assessment, a prudent contractor would allow for some minor pumping to maintain dry working conditions during periods of heavy / prolonged periods of precipitation.
Excavations	Light hydraulic excavators may undertake excavations. Excavations in excess of 1.2mbgl will require side support.



APPENDIX A

DRAWINGS



Site Plan
1 : 500

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NOTES:

C	05-02-21	Ammendments following planning comments			
B	03-02-21	Ammendments following planning comments			
A	28-01-21	Ammendments following planning comments			
Revision Number	Date	Description of Revision	Chkd	Appr	

SEEDY Architects!

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62 Chapel St
Manchester
M3 7AA

● Tel: 0161 832 5750 ● E: office@seedarchitects.co.uk ●

status

Planning

job title

163 Great Ducie Street

Location

drawing title

Site Location Plan

author MD	date 07-12-2020
checker RH	date 07-12-2020
scale 1 : 500	paper size A1

Project no. 3217	Cont.	Seed drawing no. A100	Rev. C
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Legend

 Site Boundary



CC GEOTECHNICAL LIMITED
UNIT 1 DELTIC WAY
KNOWSLEY INDUSTRIAL ESTATE
LIVERPOOL
L33 7BA
0151 545 2750

Client:

SEED Architects

Project:

163 Great Ducie Street, Manchester, M3 1FF

Title:

Aerial Site Boundary Plan

Scale:
NTS

Issue:
1

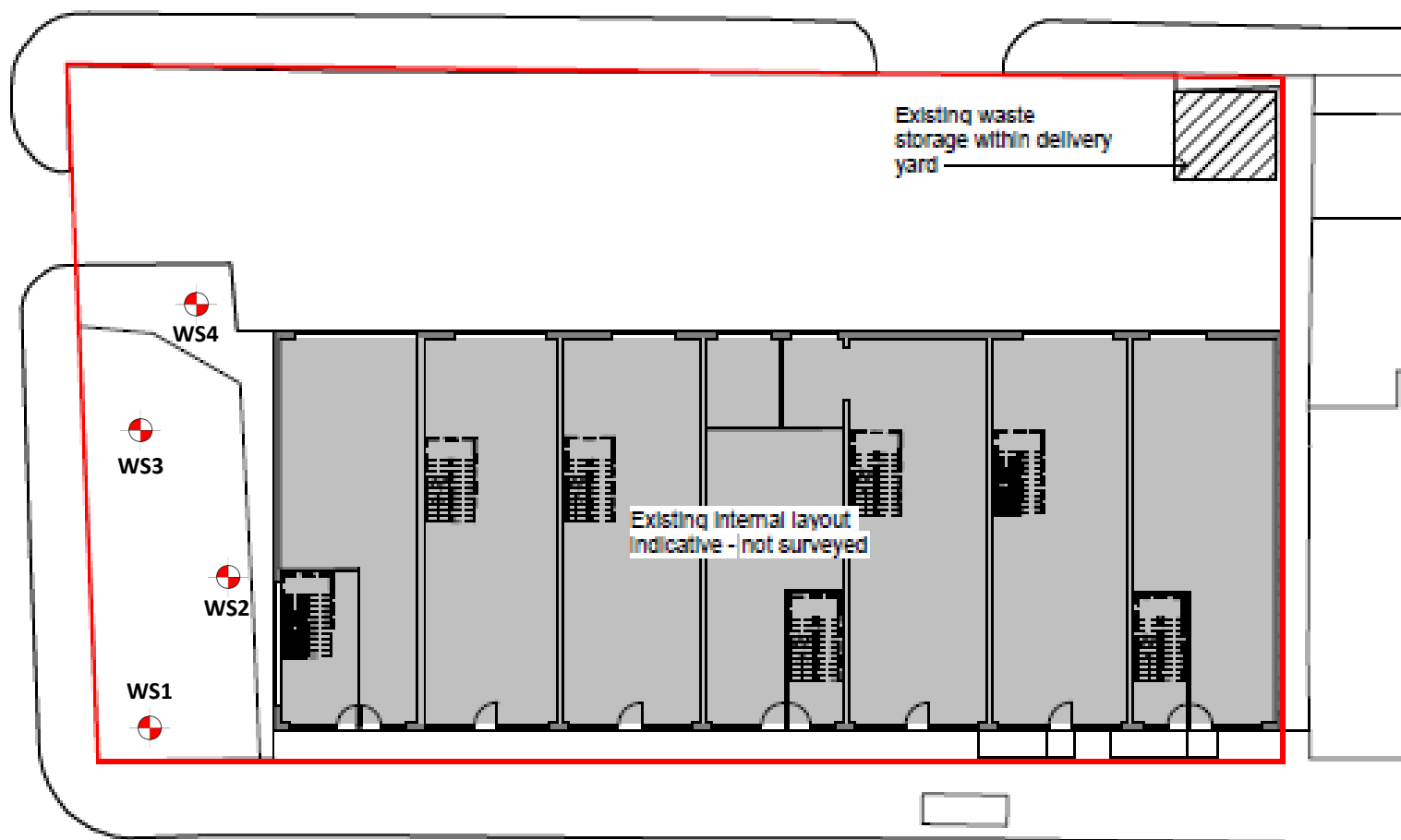
Drawn by:
SP

Date:
29/06/2021

Project No.
CCG-C-21-12359

Drawing No.
12359-1

CC GEOTECHNICAL LIMITED



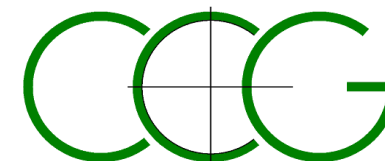
Existing Ground Floor Plan

1 : 200

Notes:

 Borehole (WS)

Background Drawing provided by Seed Architects



CC GEOTECHNICAL LIMITED
UNIT 1 DELTIC WAY
KNOWSLEY INDUSTRIAL ESTATE
LIVERPOOL
L33 7BA
0151 545 2750

Client:

Seed Architects

Project:

163 Great Ducie Street, Manchester, M3 1FF

Title:

Site Investigation Layout Plan

Scale:

As shown

Issue:

1

Drawn by:

DO

Date:

29/06/2021

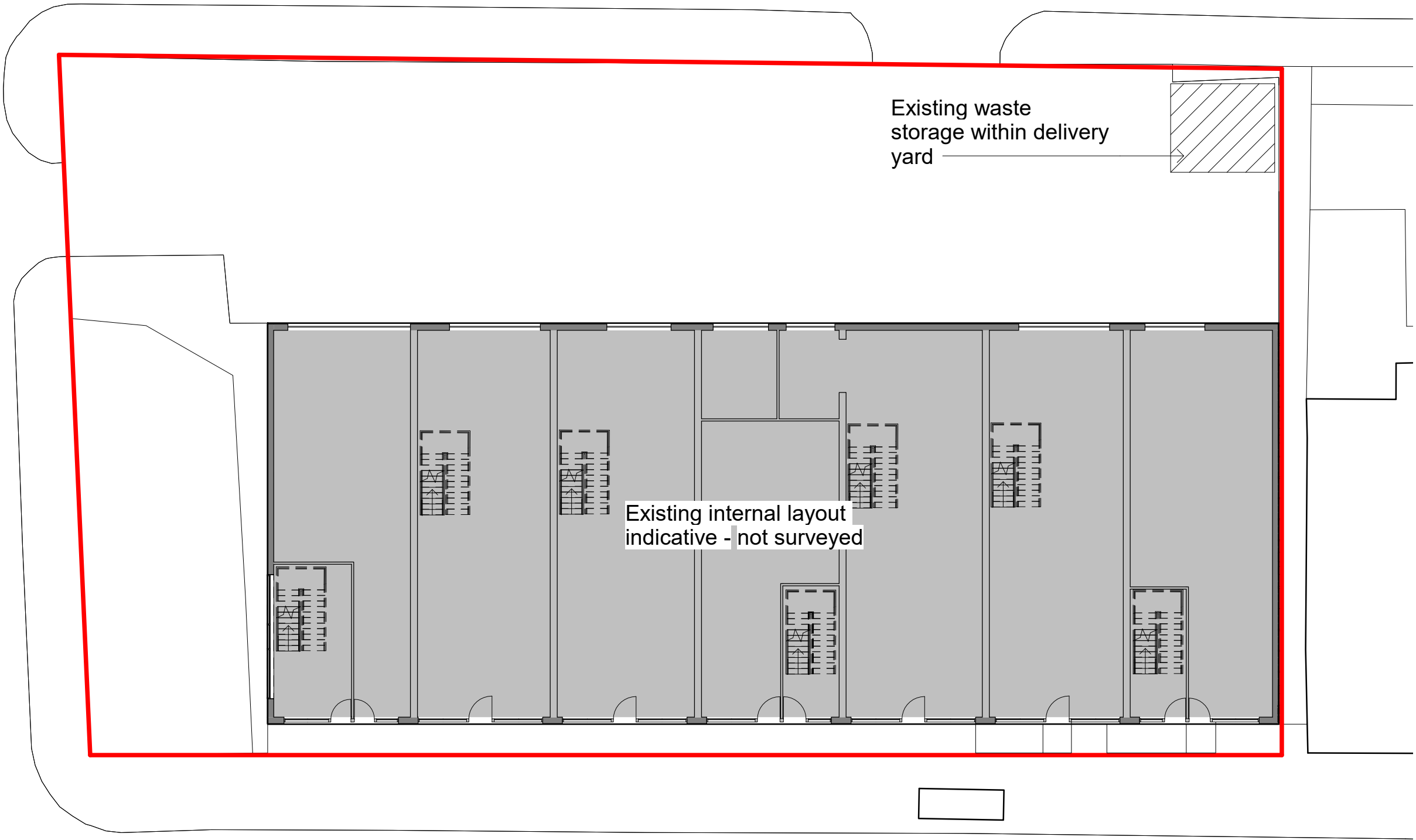
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CCG-C-21-12359

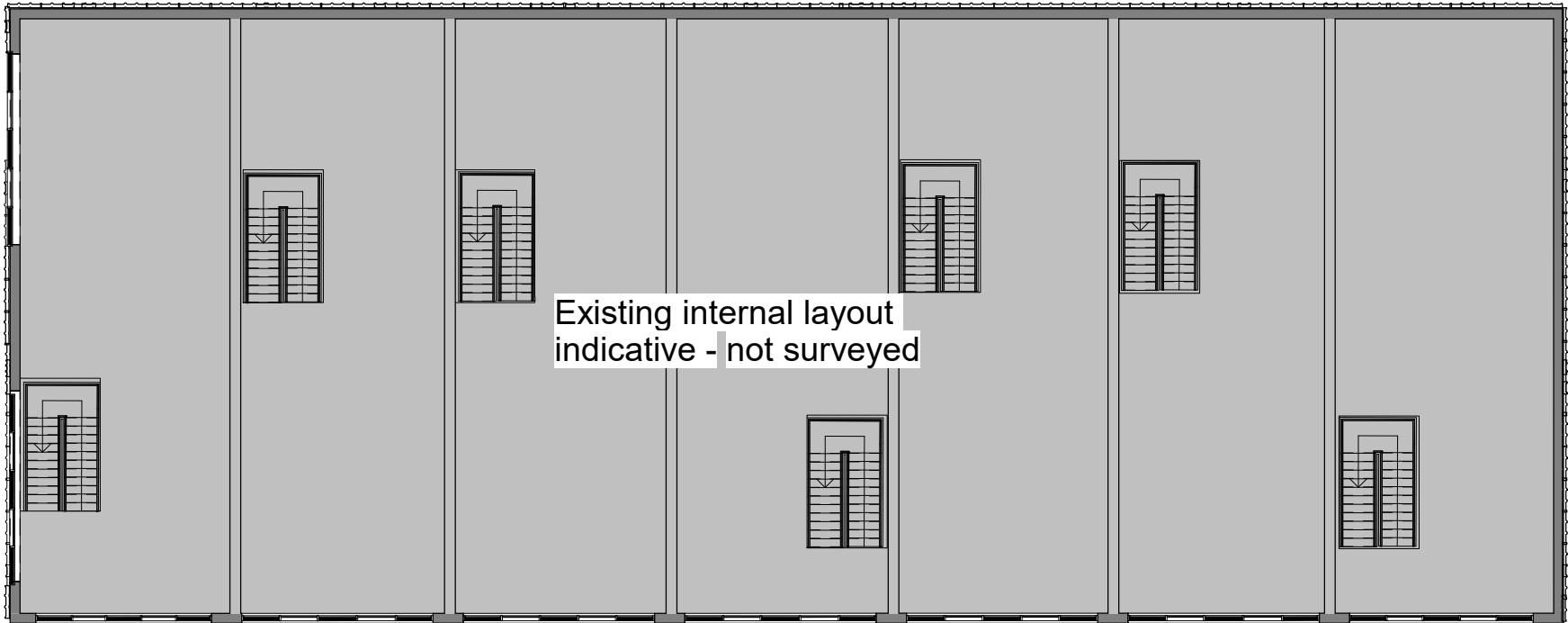
Drawing No.

12359-2

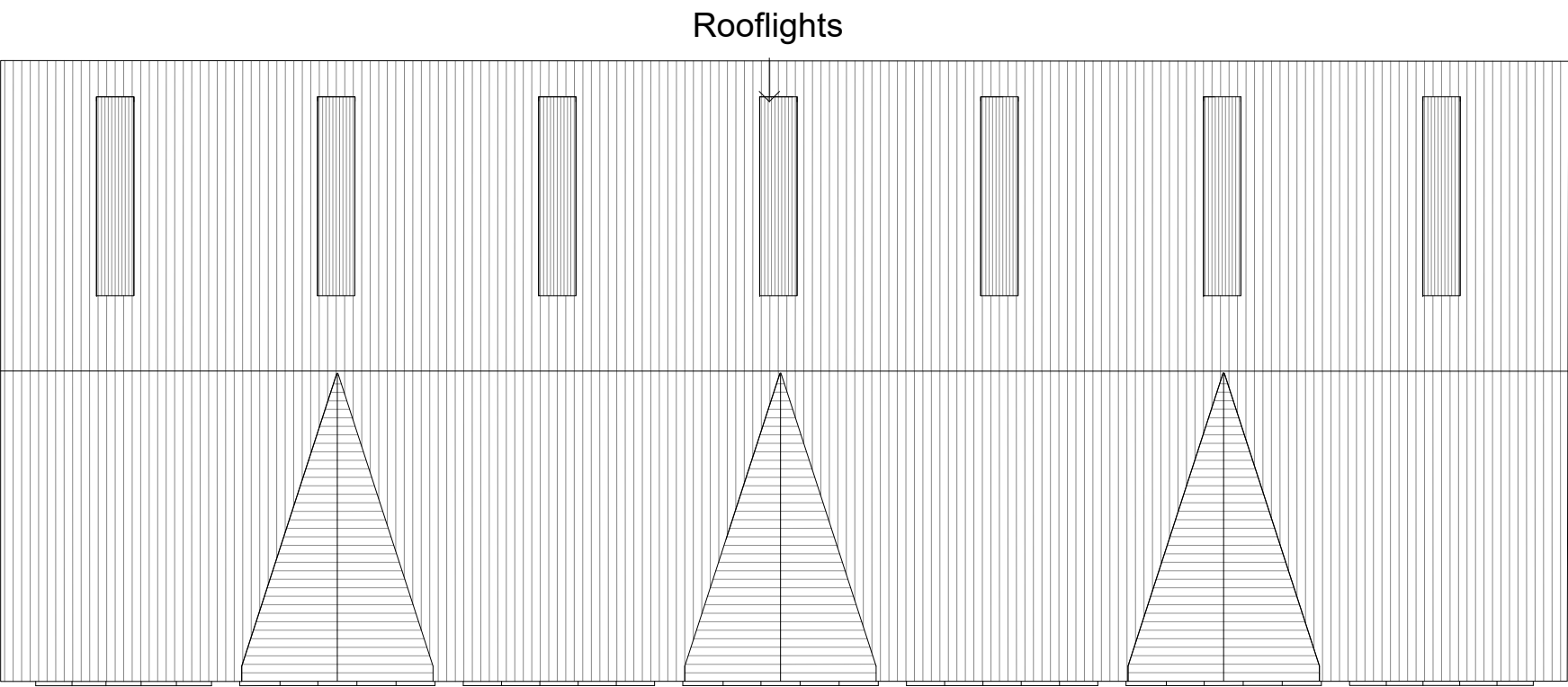
CC GEOTECHNICAL LIMITED



Existing Ground Floor Plan
1 : 200



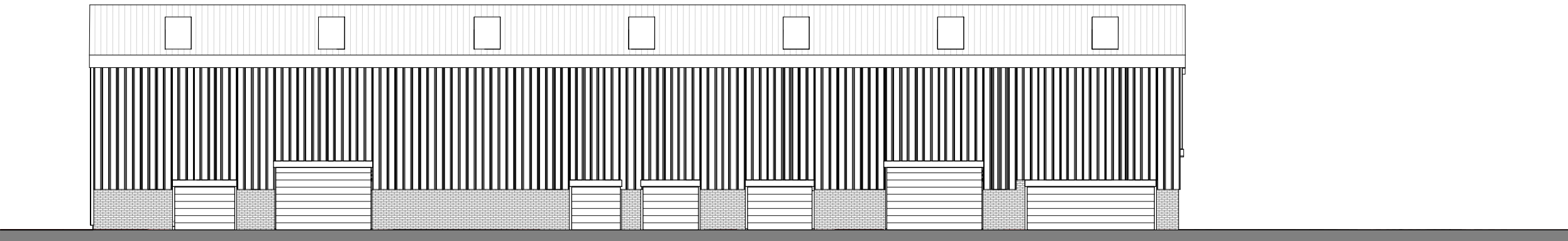
Existing First Floor Plan
1 : 200



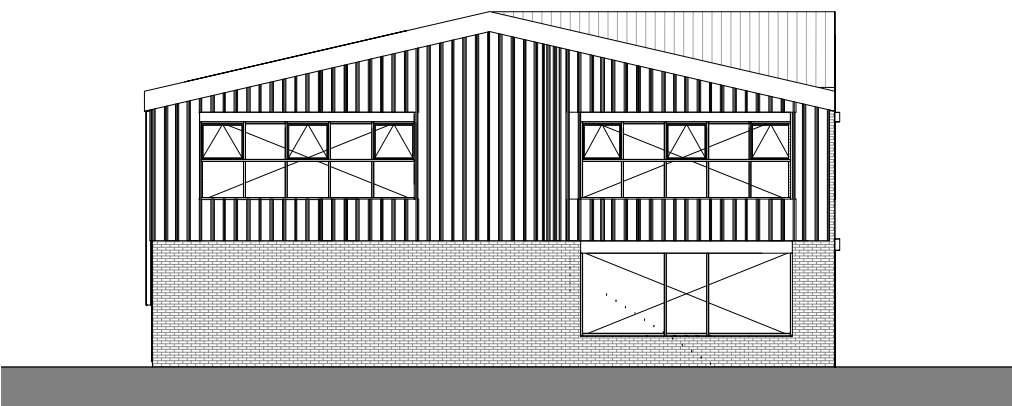
Existing Roof Plan
1 : 200



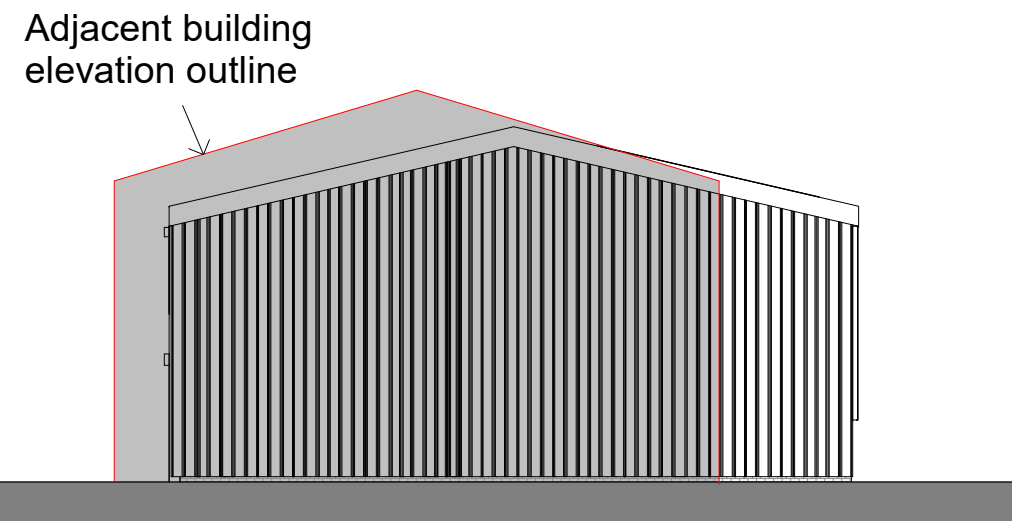
Existing East Elevation - Great Ducie Street
1 : 200



Existing West Elevation - Barker Street
1 : 200



Existing South Elevation - Langston Street
1 : 200



Existing North Elevation
1 : 200



Existing Isometric View

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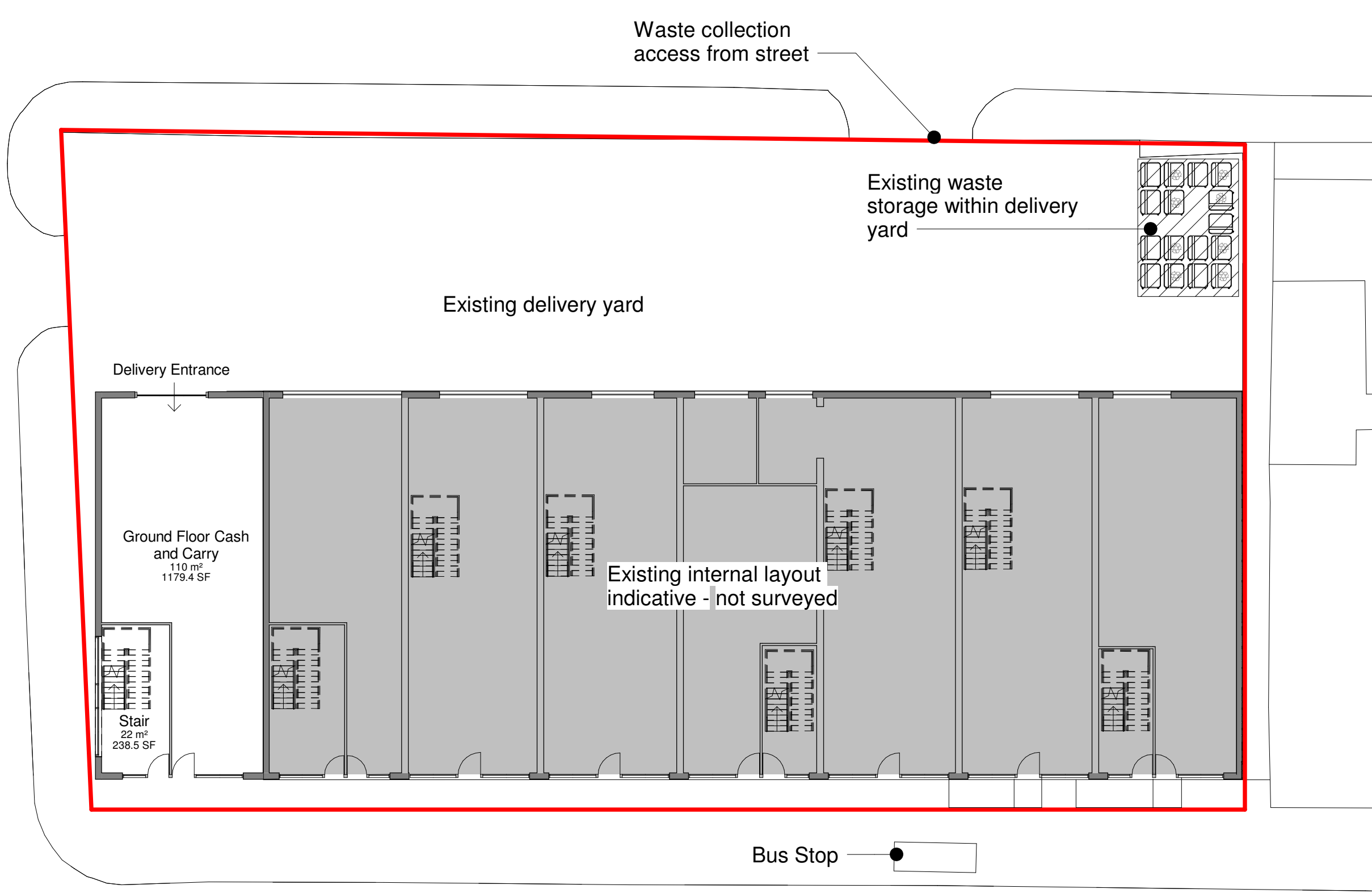
NOTES:

Revision Number	Date	Description of Revision	Chkd	Appr

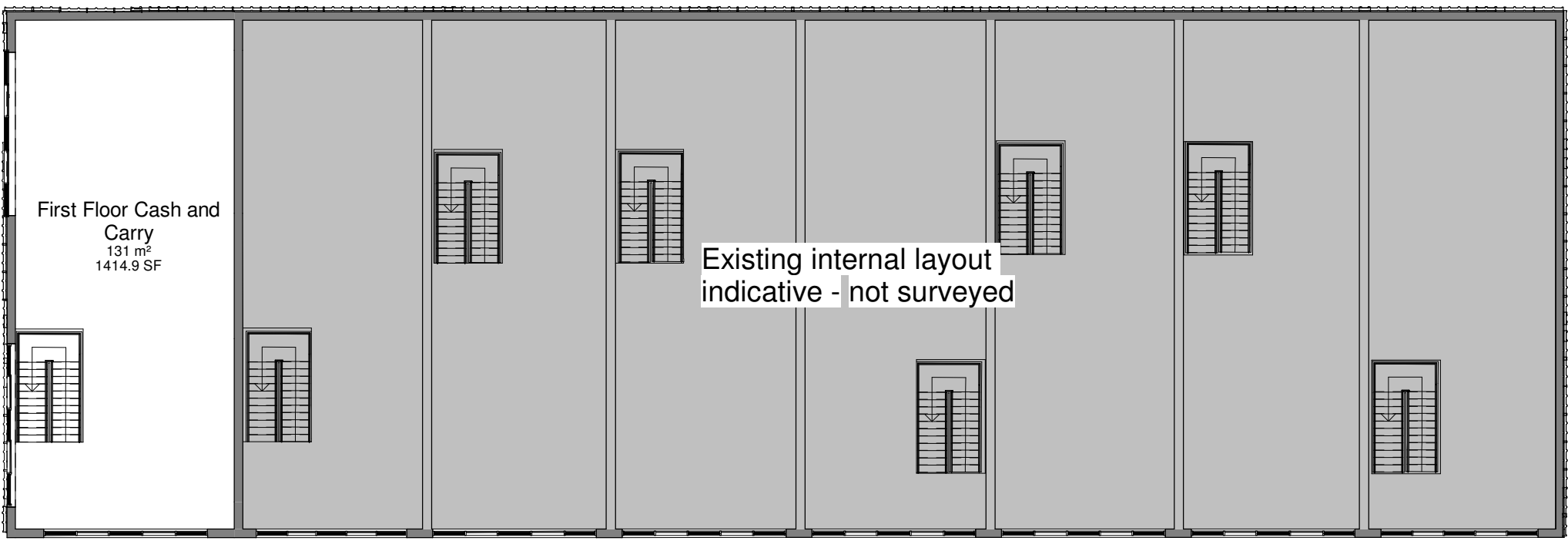
SEED Architects! The Old Police Station
62 Chapel St
Manchester
M3 7AA
● Tel: 0161 832 5750 ● E: office@seedarchitects.co.uk ●

status
Planning

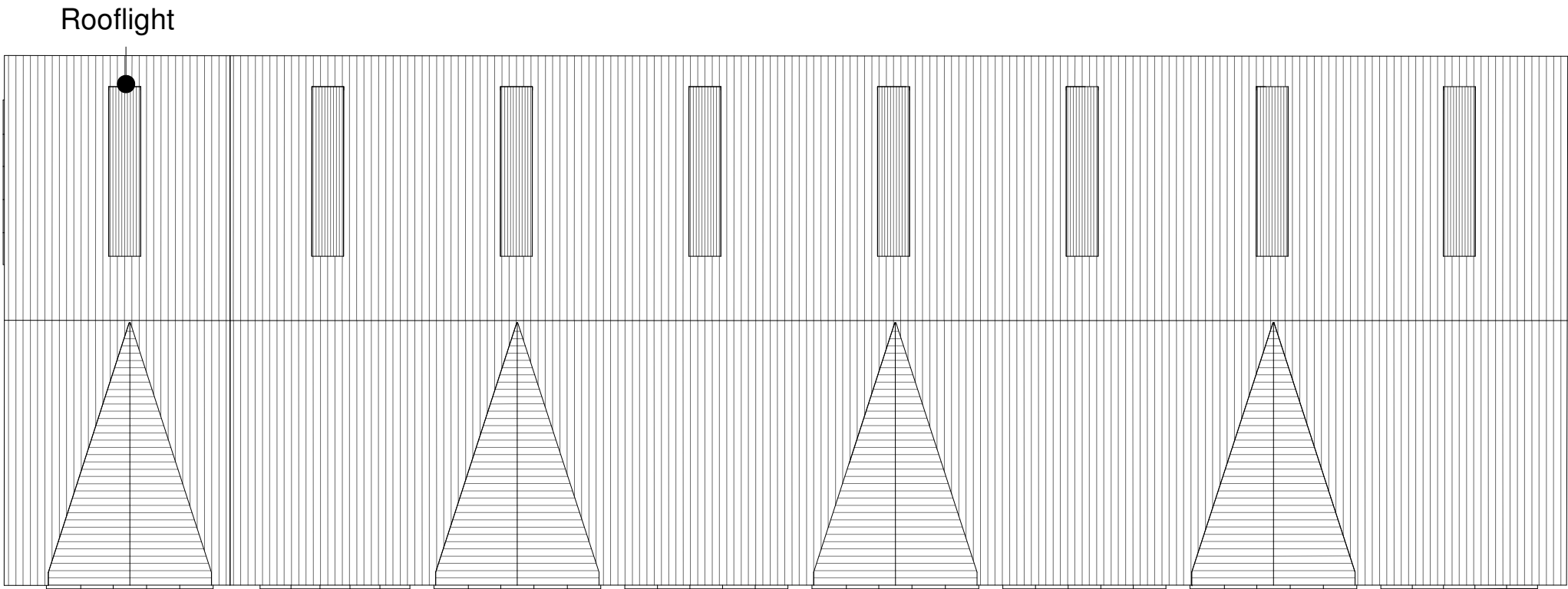
job title			
163 Great Ducie Street			
Location			
drawing title			
Existing Floor Plans and Elevations			
author		date	
MD		07-12-2020	
checker		date	
RH		07-12-2020	
scale		paper size	
1 : 200		A1	
Project no.	Cont.	Seed drawing no.	Rev.
3217		A101	



Proposed Ground Floor Plan
1 : 200



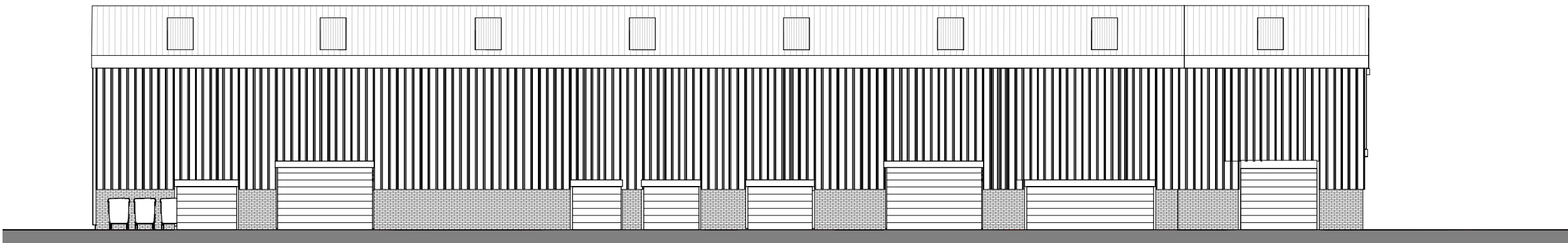
Proposed First Floor Plan
1 : 200



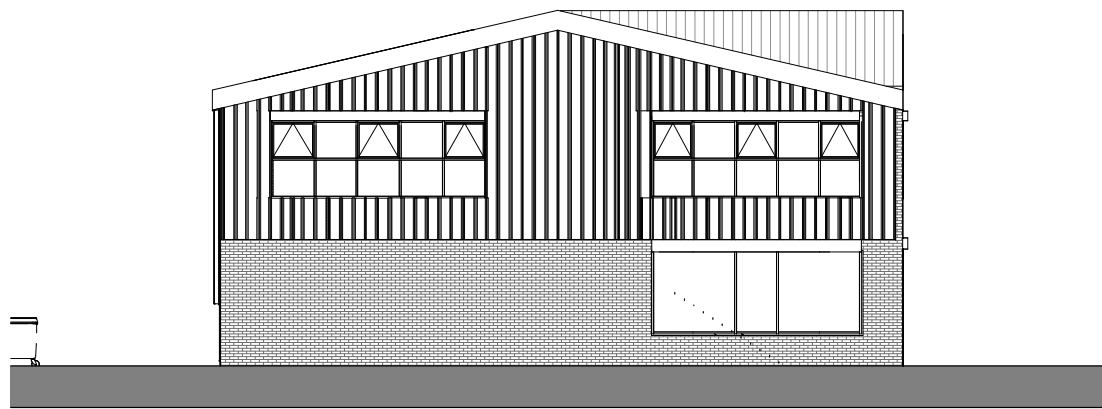
Proposed Roof Plan
1 : 200



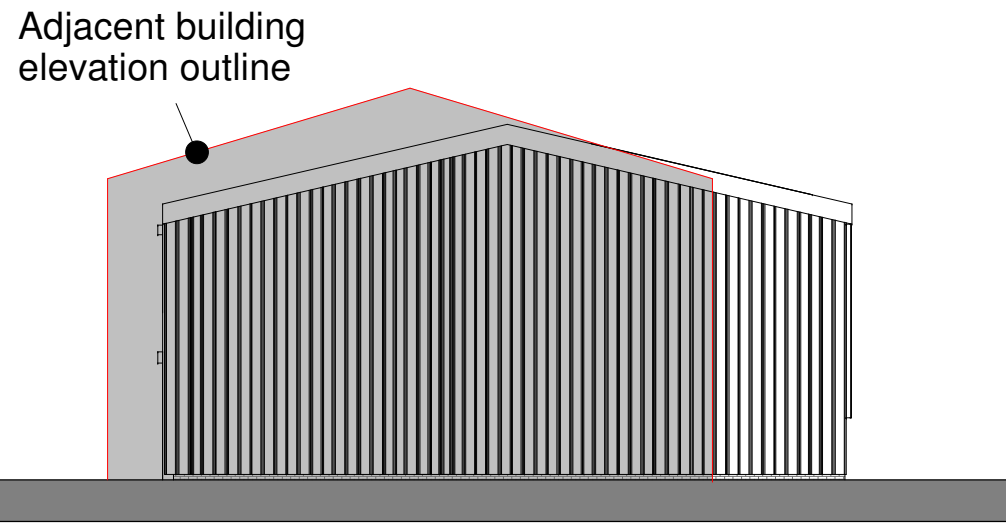
Proposed East Elevation - Great Ducie Street
1 : 200



Proposed West Elevation - Barker Street
1 : 200



Proposed South Elevation - Langston Street
1 : 200



Proposed North Elevation
1 : 200



Proposed Isometric View

©
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NOTES:

Revision Number	Date	Description of Revision	Chkd	Appr
B	22-03-21	Amendments following planning officer comments		
A	28-01-21	Amendments following planning comments		

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status
Planning

job title
163 Great Ducie Street

Location

drawing title
Proposed Floor Plans and Elevations

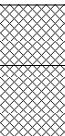
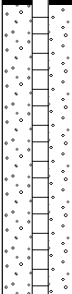
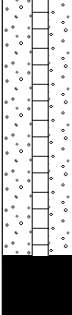
author MD	date 07-12-2020
checker RH	date 07-12-2020
scale 1 : 200	paper size A1

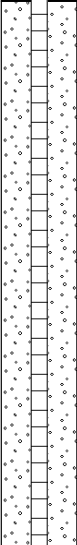
Project no. 3217	Cont.	Seed drawing no. A102	Rev. B
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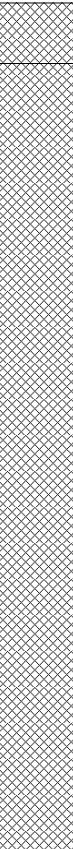
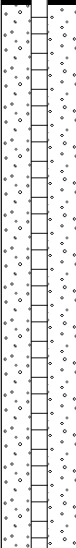


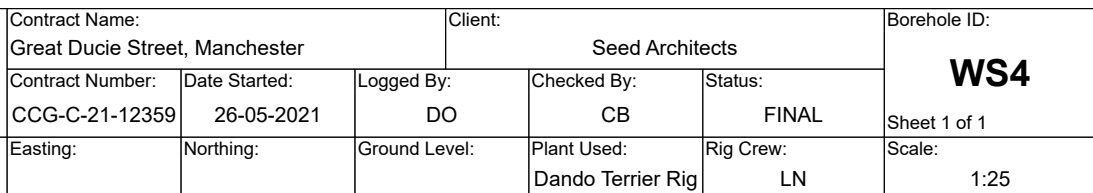
APPENDIX B

BOREHOLE LOGS

	Contract Name: Great Ducie Street, Manchester			Client: Seed Architects			Borehole ID: WS1						
	Contract Number: CCG-C-21-12359		Date Started: 26-05-2021		Logged By: DO		Checked By: CB		Status: FINAL				
	Easting:		Northing:		Ground Level:		Plant Used: Dando Terrier Rig		Rig Crew: LN				
Dynamic Sampling Borehole Log									Sheet 1 of 1				
Weather:			Termination: Refusal			SPT Hammer: N/R, Energy Ratio: N/R			Scale: 1:25				
Samples & In Situ Testing				Strata Details					Groundwater				
Depth	Sample ID	Test Result	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description			Water Strike	Backfill/ Installation			
0.00 - 1.00	U			0.20		Black silty very sandy GRAVEL. Gravel is fine to coarse sub-angular to sub-rounded limestone (MADE GROUND)			1				
0.30	B			ES				Dark brown silty very gravelly SAND. Medium cobble content. Gravel is fine to medium angular to sub-angular brick and sandstone (MADE GROUND)					
0.30								<u>GEOTEXTILE - 0.40mbgl</u>					
0.90	B	U		(2.60)					2				
1.00 - 2.00						SPT(S)N=3 (1,2/1,0,1,1)							
2.00 - 3.00	U	SPT(S)N=28 (1,2/3,4,9,12)							3				
		SPT(S)N=50 (7,15/50 for 285mm)		2.80		Reddish brown weathered SANDSTONE							
				3.00		End of Borehole at 3.00m							
									4				
									5				
Start & End of Shift Observations					Borehole Diameter		Casing Diameter		Remarks:				
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)	1 hour hand excavating 1.20mbgl service avoidance pit				
Chiselling					Installation				Water Strikes				
From (m)	To (m)	Duration	Remarks	Top (m)	Base (m)	Type	Dia (mm)	Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
				0.00	1.00	PLAIN					0		Dry
				1.00	2.80	SLOTTED							
CC GEOTECHNICAL LTD 0151 545 2750 www.ccgeotechnical.com													

	Contract Name: Great Ducie Street, Manchester				Client: Seed Architects			Borehole ID: WS2						
	Contract Number: CCG-C-21-12359		Date Started: 26-05-2021		Logged By: DO	Checked By: CB	Status: FINAL	Sheet 1 of 1						
	Easting:		Northing:		Ground Level:	Plant Used: Dando Terrier Rig	Rig Crew: LN	Scale: 1:25						
Dynamic Sampling Borehole Log														
Weather:					Termination: Refusal					SPT Hammer: N/R, Energy Ratio: N/R				
Samples & In Situ Testing					Strata Details					Groundwater				
Depth	Sample ID	Test Result		Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description			Water Strike	Backfill/ Installation			
0.00 - 1.00	U				0.20		Black silty very sandy GRAVEL. Gravel is fine to coarse sub-angular to sub-rounded sandstone (MADE GROUND)							
0.40	B						Dark brown silty very gravelly SAND. Medium cobble content. Gravel is fine to medium angular to sub-angular brick, sandstone and ash (MADE GROUND)							
0.50	ES						<u>GEOTEXTILE - 0.40mbgl</u>							
0.80	B													
1.00 - 2.00	U	SPT(S)N=2 (1,1/1,0,0,1)			(2.60)					1				
2.00 - 3.00	U	SPT(S)N=26 (1,2/3,3,8,12)								2				
														
														
														
														
														
														
														
														
														
														
														
														
														
														
														
														
														
														
														
														
														
														
														
														
														
														

	Contract Name: Great Ducie Street, Manchester				Client: Seed Architects				Borehole ID: WS3				
	Contract Number: CCG-C-21-12359		Date Started: 26-05-2021		Logged By: DO		Checked By: CB		Status: FINAL				
	Easting:		Northing:		Ground Level:		Plant Used: Dando Terrier Rig		Rig Crew: LN				
Dynamic Sampling Borehole Log										Sheet 1 of 1			
										Scale: 1:25			
Weather:				Termination: Refusal				SPT Hammer: N/R, Energy Ratio: N/R					
Samples & In Situ Testing				Strata Details						Groundwater			
Depth	Sample ID	Test Result	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description				Water Strike	Backfill/ Installation		
0.00 - 1.00	U			0.20		Black silty very sandy GRAVEL. Gravel is fine to coarse sub-angular to sub-rounded limestone (MADE GROUND)				1			
0.40 0.40	B ES					Dark brown silty very gravelly SAND. Medium cobble content. Gravel is fine to medium angular to sub-angular brick, ash and sandstone (MADE GROUND) GEOTEXTILE - 0.40mbgl							
0.80	B												
1.00 - 2.00	U	SPT(S)N=4 (1,1/1,1,2,0)		(2.60)						2			
2.00 - 3.00	U	SPT(S)N=31 (2,2/2,4,10,15)											
				2.80		Reddish brown weathered SANDSTONE				3			
				3.00		End of Borehole at 3.00m							
										4			
										5			
Start & End of Shift Observations					Borehole Diameter		Casing Diameter		Remarks:				
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)	1 hour hand excavating 1.20mbgl service avoidance pit				
Chiselling					Installation				Water Strikes				
From (m)	To (m)	Duration	Remarks	Top (m)	Base (m)	Type	Dia (mm)	Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
				0.00	1.00	PLAIN					0		Dry
				1.00	2.80	SLOTTED							
CC GEOTECHNICAL LTD 0151 545 2750 www.ccgeotechnical.com													



Weather:	Termination: Refusal	SPT Hammer: N/R, Energy Ratio: N/R
----------	----------------------	------------------------------------

Samples & In Situ Testing				Strata Details						Groundwater	
Depth	Sample ID	Test Result	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description				Water Strike	Backfill/ Installation
0.00 - 1.00	U			0.20		Black silty very sandy GRAVEL. Gravel is fine to coarse sub-angular to sub-rounded limestone (MADE GROUND)					
0.50	B					Dark brown silty very gravelly SAND. Medium cobble content. Gravel is fine to medium angular to sub-angular brick (MADE GROUND)					
0.50	ES					GEOTEXTILE - 0.40mbgi					
0.90	B			(1.00)						1	
1.00 - 2.00	U	SPT(S)N=6 (1,1/1,1,2,2) HVP=50		1.20		Firm brown slightly sandy slightly gravelly silty CLAY. Gravel is fine to medium sub-rounded sandstone					
				(0.50)							
				1.70		Dense brown very sandy silty GRAVEL. Gravel is fine to coarse sub-angular to sub-rounded sandstone				2	
-2.00 - 3.00	U	SPT(S)N=35 (1,2/2,5,11,17)		(1.10)							
				2.80		Reddish brown weathered SANDSTONE					
		SPT(S)50 (25 for 140mm/50 for 135mm)		3.00		End of Borehole at 3.00m				3	
										4	
										5	

Start & End of Shift Observations					Borehole Diameter		Casing Diameter		Remarks:					
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)	1 hour hand excavating 1.20mbgl service avoidance pit					
Chiselling					Installation				Water Strikes					
									Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
From (m)	To (m)	Duration	Remarks		Top (m)	Base (m)	Type	Dia (mm)				0		Dry
CC GEOTECHNICAL LTD 0151 545 2750 www.ccgeotechnical.com														



APPENDIX C

GAS & GROUNDWATER MONITORING

GAS AND WATER MONITORING RESULTS



	Date:	03-Jun-21	17-Jun-21	23-Jun-21	02-Jul-21								
	Visit Number	1	2	3	4								
	Atmos Press mb	1014	1012	1019	1012								
	Pressure Trend												
	Air Temp °C	18	17	17	17								
	Cloud cover	Overcast	Overcast	Overcast	Overcast								
	Wind velocity	Light breeze	Light breeze	Light breeze	Light breeze								
	Precipitation	Dry	Dry	Dry	Dry								
	State of Ground	Dry	Dry	Dry	Dry								
WS1	CH4 (%):	Nil	Nil	Nil	Nil								
	CO2 (%):	1.4	1.3	1.1	1.2								
	O2 (%):	13.1	14.0	13.9	14.1								
	H2S (ppm):	Nil	Nil	Nil	Nil								
	CO (ppm):	Nil	Nil	Nil	Nil								
	PID (ppm):	0.0	0.0	0.0	0.00								
	Flow (l/hr):	<0.1	<0.1	<0.1	<0.1								
WS2	Water Level (mbgl):	Dry	Dry	Dry	Dry								
	CH ₄ (%):	Nil	Nil	Nil	Nil								
	CO ₂ (%):	0.3	0.2	0.2	0.1								
	O ₂ (%):	20.0	20.0	19.9	20.1								
	H ₂ S (ppm):	Nil	Nil	Nil	Nil								
	CO (ppm):	Nil	Nil	Nil	Nil								
	PID (ppm):	0.0	0.0	0.0	0.00								
WS3	Flow (l/hr):	<0.1	<0.1	<0.1	<0.1								
	Water Level (mbgl):	Dry	Dry	Ddry	Dry								
	CH4 (%):	Nil	Nil	Nil	Nil								
	CO2 (%):	Nil	Nil	Nil	Nil								
	O2 (%):	20.8	20.3	20.2	20.3								
	H2S (ppm):	Nil	Nil	Nil	Nil								
	CO (ppm):	Nil	Nil	Nil	Nil								
	PID (ppm):	0.0	0.0	0.0	0.0								
	Flow (l/hr):	<0.1	<0.1	<0.1	<0.1								
	Water Level (mbgl):	Dry	Dry	Dry	Dry								

CCG-CMS-FO-129

Issue 2

Job No: CCG-C-21-12359

Site: Great Ducie Street, Manchester

Instrument:

GFM436

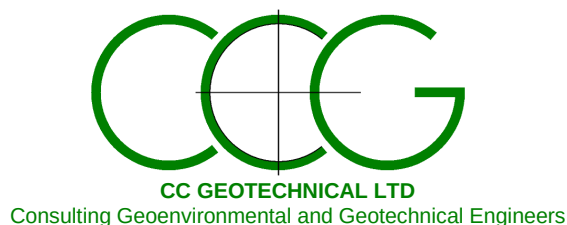


APPENDIX D

SOIL ENGINEERING TEST DATA

Units 1 & 2
Deltic Place
Deltic Way
Knowsley Industrial Estate
Liverpool
L33 7BU

Telephone: (0151) 545 2750
Fax: (0151) 548 7892
Email: enquiries@ccgeotechnical.com
www.ccgeotechnical.com



LABORATORY REPORT

CONTRACT NUMBER: CCG-C-21-12359

CONTRACT TITLE: GREAT DUCIE STREET, MANCHESTER

CLIENT: SEED ARCHITECTS

DATE RECEIVED: 27/05/21
DATE COMMENCED: 27/05/21
DATE COMPLETED: 09/06/21
REPORT DATE: 09/06/21

Test Description	Qty
Determination of Moisture Content BS 1377-2:1990 (a)	1
Determination of Liquid & Plastic Limits BS 1377-2:1990 (a)	1
Particle Size Distribution BS 1377-2:1990 (a)	1

Notes: Observations and interpretations are not accredited by UKAS
All testing undertaken at laboratory permanent facilities
denotes non-accredited test
a denotes UKAS accredited test
s denotes test undertaken by approved subcontractor
Test results only relate to the samples tested

This report is issued in accordance with the requirements of the United Kingdom Accreditation Services and EN ISO/IEC 17025:2017. The results reported herein relate only to the material supplied to the laboratory. This report shall not be reproduced except in full, without the prior written approval of the laboratory.

Approved Signatories: Chris Bolan (Managing Director) – Daniel Kerfoot (Laboratory Manager)

SUMMARY OF LABORATORY SOIL TEST RESULTS

BH / TP / WS Number	Sample Type	Depth From (m)	Depth To (m)	Moisture Content (%)	Bulk Density (Mg/m ³)	Dry Density (Mg/m ³)	Shear Strength (kN/m ²)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Passing 0.425mm (%)	Soil Classification	UKAS accredited test (Y/N)	Description / Test Method Samples described in accordance with BS EN ISO 14688-2 2004
WS4	WS	1.30	1.30	29	-	-	-	37	17	20	99	CI	Y	Brown slightly sandy slightly gravelly silty CLAY. Gravel is fine subrounded sandstone. (BS1377Pt2:3.2,4,4,5)
WS4	WS	1.90	1.90	-	-	-	-	-	-	-	-	-	Y	Brown very sandy silty GRAVEL. Gravel is fine to coarse subangular to subrounded sandstone. (BS1377Pt2:9.2)

SITE: GREAT DUCIE STREET, MANCHESTER (CCG-C-21-12359)
 CLIENT: SEED ARCHITECTS

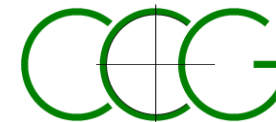
DATE: 09.06.21

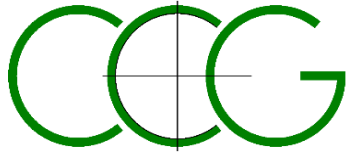
Key:- BD = Bulk Disturbed; SD = Small Disturbed; U100 = Undisturbed 100mm; WS = Window Sample

CL = Low Plasticity; CI = Intermediate; CH = High; CV = Very high; CE = Extremely high; NP = Non-plastic

(* Denotes Hand Shear Vane test result)

Sample description not accredited by UKAS

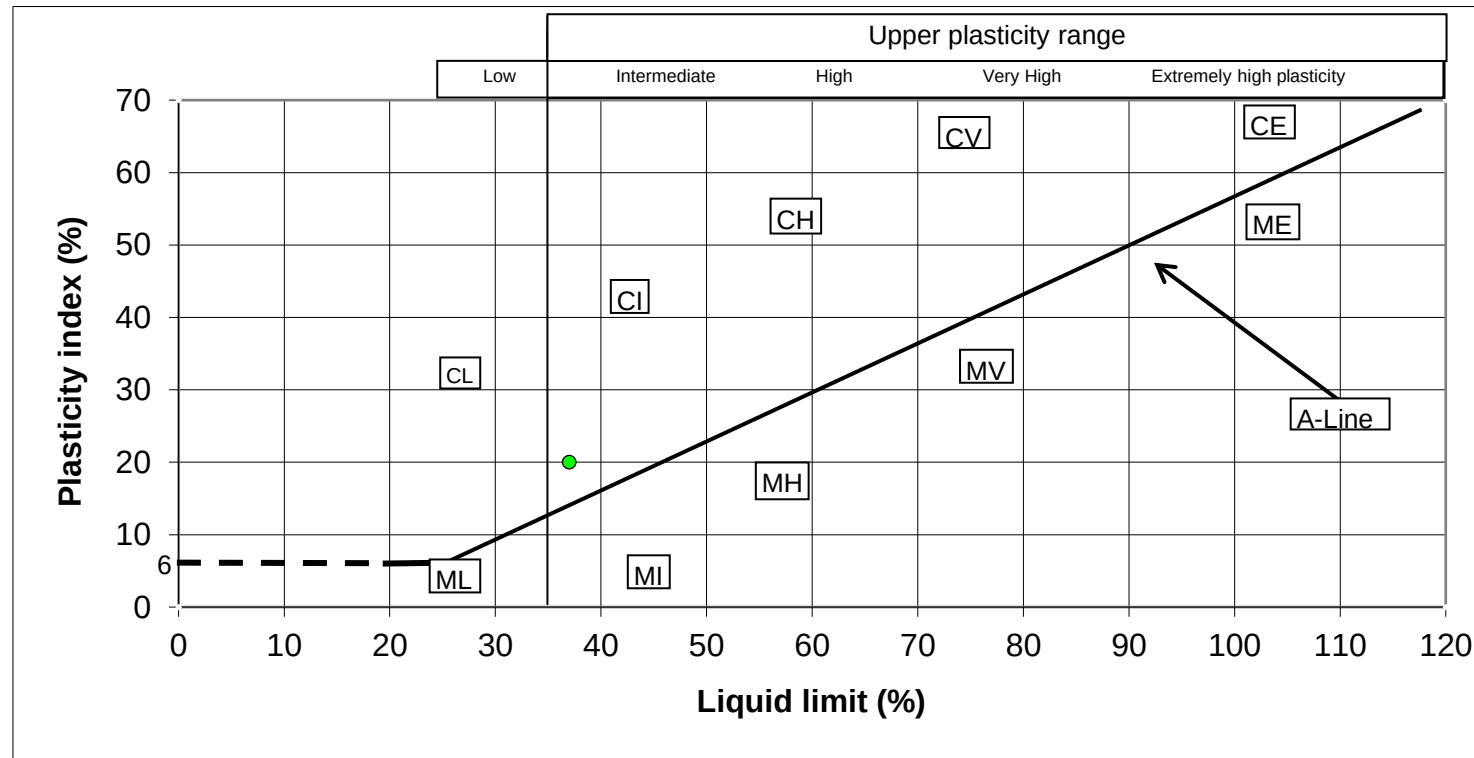




ATTERBERG TEST RESULT SHEET

BS 1377:Part 2:1990:cl 4.4,5

SILT (M-SOIL), M plots below A-Line , CLAY,C, plots above A-Line, M and C may be combined as FINE SOIL, F.



BH	Sample Depth	Liquid limit	Plasticity index
WS4	1.30	37.0	20.0



4514

APPROVED BY	DK
-------------	----

CLIENT: SEED ARCHITECTS	SITE: GREAT DUCIE STREET, MANCHESTER (CCG-C-21-12359)
-------------------------	---

CCG-CMS-FO-204 Issue 2



CC Geotechnical Ltd
Tel: 0151 545 2750
e: lab@ccgeotechnical.com

PARTICLE SIZE DISTRIBUTION

Job Ref

CCG-C-21-12359

Borehole/Pit No.

WS4

Site Name

GREAT DUCIE STREET, MANCHESTER

Sample No.

1

Specimen
Description

Brown very sandy silty GRAVEL

Depth, m

1.90

Specimen
Reference

Specimen
Depth

m

Sample Type

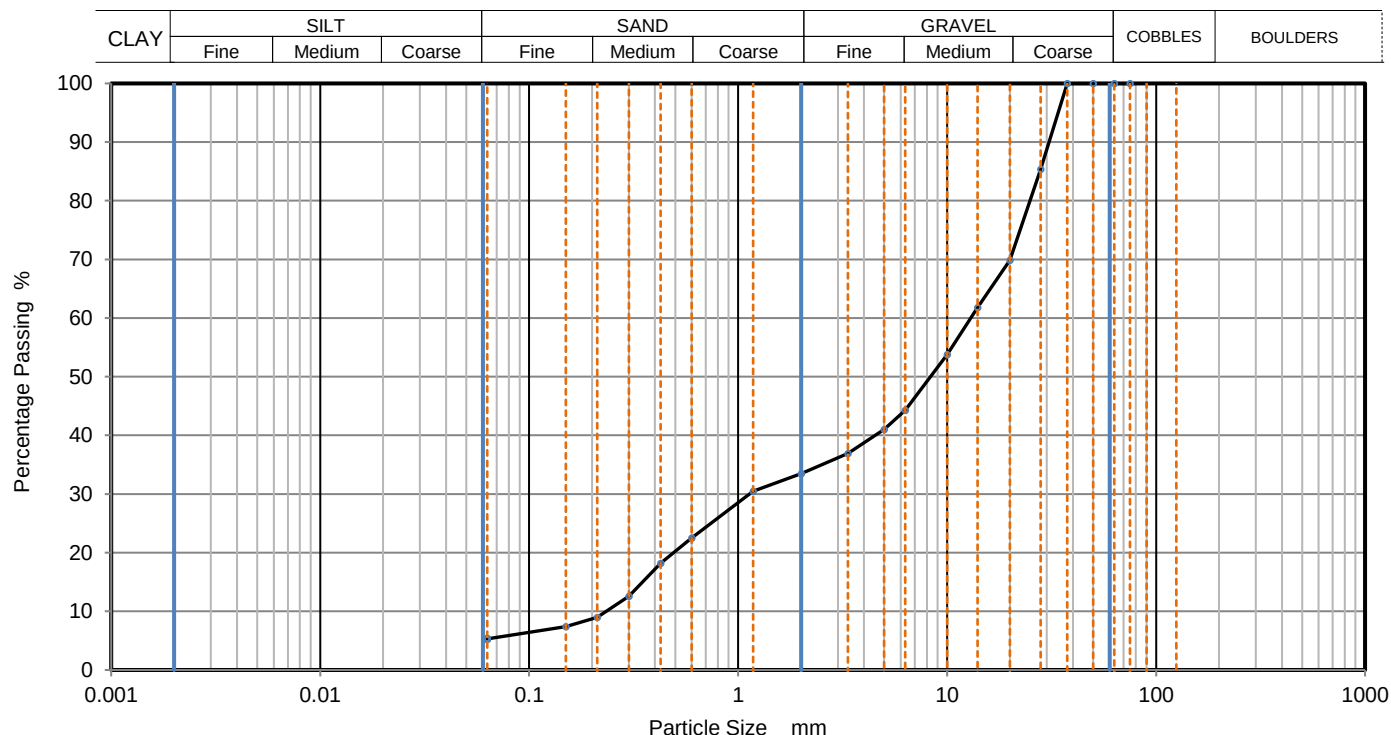
WS

Test Method

BS1377:Part 2:1990, clause 9.2

KeyLAB ID

CCGL202106099



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
75	100		
63	100		
50	100		
37.5	100		
28	85		
20	70		
14	62		
10	54		
6.3	44		
5	41		
3.35	37		
2	34		
1.18	31		
0.6	23		
0.425	18		
0.3	13		
0.212	9		
0.15	7		
0.063	5		

Dry Mass of sample, g

Sample Proportions	% dry mass
Very coarse	0
Gravel	67
Sand	28
Fines <0.063mm	5

Grading Analysis		
D100	mm	
D60	mm	13
D30	mm	1.13
D10	mm	0.234
Uniformity Coefficient		55
Curvature Coefficient		0.42

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operator	Checked	Approved	Sheet printed	Fig
JE	DK	DK	09/06/2021 11:18	1
				Sheet



APPENDIX E

SOIL CHEMICAL TEST DATA



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THE ENVIRONMENTAL LABORATORY LTD

Analytical Report Number: 21-34001

Issue: 1

Date of Issue: 07/06/2021

Contact: Daniel O'Regan

Customer Details: CC Geotechnical Ltd
Unit 1 & 2 Deltic Place
Deltic Way
Liverpool
Merseyside L33 7BA

Quotation No: Q14-00045

Order No: Not Supplied

Customer Reference: 21-12359

Date Received: 28/05/2021

Date Approved: 07/06/2021

Details: Great Ducie Street, Manchester

Approved by:

Mike Varley, Technical Manager

Any comments, opinions or interpretations expressed herein are outside the scope of UKAS accreditation (Accreditation Number 2683)

This report may only be reproduced in full



Sample Summary

Report No.: 21-34001, issue number 1

Elab No.	Client's Ref.	Date Sampled	Date Scheduled	Description	Deviations
239043	WS1 0.30	27/05/2021	28/05/2021	Sandy loam	
239044	WS2 0.50	27/05/2021	28/05/2021	Sandy silty loam	
239045	WS3 0.40	27/05/2021	28/05/2021	Loamy sand	
239046	WS4 0.50	27/05/2021	28/05/2021	Sandy silty loam	

Results Summary

Report No.: 21-34001, issue number 1

ELAB Reference				239043	239044	239045	239046
Customer Reference							
Sample ID							
Sample Type				SOIL	SOIL	SOIL	SOIL
Sample Location				WS1	WS2	WS3	WS4
Sample Depth (m)				0.30	0.50	0.40	0.50
Sampling Date				27/05/2021	27/05/2021	27/05/2021	27/05/2021
Determinand	Codes	Units	LOD				
Soil sample preparation parameters							
Material removed	N	%	0.1	49.4	59.0	50.0	60.7
Description of Inert material removed	N		0	Stones,clinker	Stones,clinker	Stones,clinker	Stones,clinker
Metals							
Arsenic	M	mg/kg	1	11.2	12.3	5.9	13.4
Cadmium	M	mg/kg	0.5	1.5	1.4	0.9	0.7
Chromium	M	mg/kg	5	40.7	35.2	28.3	25.5
Copper	M	mg/kg	5	52.7	51.9	23.3	57.7
Lead	M	mg/kg	5	156	172	56.1	342
Mercury	M	mg/kg	0.5	< 0.5	< 0.5	< 0.5	0.7
Nickel	M	mg/kg	5	44.1	37.3	29.1	26.4
Selenium	M	mg/kg	1	< 1.0	< 1.0	< 1.0	< 1.0
Zinc	M	mg/kg	5	285	248	164	202
Anions							
Water Soluble Sulphate	M	g/l	0.02	0.07	0.02	< 0.02	0.02
Inorganics							
Free Cyanide	N	mg/kg	1	< 1.0	< 1.0	< 1.0	< 1.0
Hexavalent Chromium	N	mg/kg	0.8	< 0.8	< 0.8	< 0.8	< 0.8
Total Sulphide	N	mg/kg	2	< 2	< 2	< 2	< 2
Acid Soluble Sulphate (SO4)	U	%	0.02	0.03	0.03	< 0.02	0.02
Water Soluble Boron	N	mg/kg	0.5	< 0.5	< 0.5	< 0.5	< 0.5
Miscellaneous							
pH	M	pH units	0.1	8.1	8.4	8.6	8.4
Soil Organic Matter	U	%	0.1	5.1	5.0	4.9	3.7
Polyaromatic hydrocarbons							
Naphthalene	M	mg/kg	0.1	< 0.1	< 0.1	0.1	< 0.1
Acenaphthylene	M	mg/kg	0.1	0.1	< 0.1	< 0.1	< 0.1
Acenaphthene	M	mg/kg	0.1	0.3	< 0.1	0.5	0.1
Fluorene	M	mg/kg	0.1	0.2	< 0.1	0.3	< 0.1
Phenanthrene	M	mg/kg	0.1	1.4	0.6	2.5	0.5
Anthracene	M	mg/kg	0.1	0.5	0.2	0.7	0.2
Fluoranthene	M	mg/kg	0.1	3.2	2.0	4.6	1.2
Pyrene	M	mg/kg	0.1	3.1	2.1	4.4	1.1
Benzo(a)anthracene	M	mg/kg	0.1	1.8	1.2	2.6	0.7
Chrysene	M	mg/kg	0.1	3.4	2.3	4.1	1.0
Benzo(b)fluoranthene	M	mg/kg	0.1	3.1	2.3	3.6	0.9
Benzo(k)fluoranthene	M	mg/kg	0.1	3.1	2.5	3.6	1.0
Benzo(a)pyrene	M	mg/kg	0.1	3.2	2.5	3.5	1.0
Indeno(1,2,3-cd)pyrene	M	mg/kg	0.1	3.8	2.9	2.4	1.1
Dibenzo(a,h)anthracene	M	mg/kg	0.1	1.5	1.1	1.2	0.2
Benzo[g,h,i]perylene	M	mg/kg	0.1	4.2	2.8	4.6	1.3
Total PAH(16)	M	mg/kg	0.4	32.9	22.5	38.7	10.5

Results Summary

Report No.: 21-34001, issue number 1

ELAB Reference	239043	239044	239045	239046
Customer Reference				
Sample ID				
Sample Type	SOIL	SOIL	SOIL	SOIL
Sample Location	WS1	WS2	WS3	WS4
Sample Depth (m)	0.30	0.50	0.40	0.50
Sampling Date	27/05/2021	27/05/2021	27/05/2021	27/05/2021

Determinand	Codes	Units	LOD				
BTEX							
Benzene	M	ug/kg	10	< 10.0	< 10.0	< 10.0	< 10.0
Toluene	M	ug/kg	10	< 10.0	< 10.0	< 10.0	< 10.0
Ethylbenzene	M	ug/kg	10	< 10.0	< 10.0	< 10.0	< 10.0
Xylenes	M	ug/kg	10	< 10.0	< 10.0	< 10.0	< 10.0
TPH CWG							
>C5-C6 Aliphatic	N	mg/kg	0.01	< 0.01	< 0.01	< 0.01	< 0.01
>C6-C8 Aliphatic	N	mg/kg	0.01	< 0.01	< 0.01	< 0.01	< 0.01
>C8-C10 Aliphatic	N	mg/kg	1	< 1.0	3.2	< 1.0	< 1.0
>C10-C12 Aliphatic	N	mg/kg	1	< 1.0	5.8	< 1.0	< 1.0
>C12-C16 Aliphatic	N	mg/kg	1	2.4	26.3	3.9	< 1.0
>C16-C21 Aliphatic	N	mg/kg	1	21.7	78.9	26.6	6.0
>C21-C35 Aliphatic	N	mg/kg	1	862	2000	946	249
>C35-C40 Aliphatic	N	mg/kg	1	516	1260	626	204
>C5-C7 Aromatic	N	mg/kg	0.01	< 0.01	< 0.01	< 0.01	< 0.01
>C7-C8 Aromatic	N	mg/kg	0.01	< 0.01	< 0.01	< 0.01	< 0.01
>C8-C10 Aromatic	N	mg/kg	1	< 1.0	< 1.0	< 1.0	< 1.0
>C10-C12 Aromatic	N	mg/kg	1	< 1.0	< 1.0	< 1.0	< 1.0
>C12-C16 Aromatic	N	mg/kg	1	< 1.0	< 1.0	< 1.0	< 1.0
>C16-C21 Aromatic	N	mg/kg	1	13.9	6.7	15.4	4.3
>C21-C35 Aromatic	N	mg/kg	1	829	171	876	250
>C35-C40 Aromatic	N	mg/kg	1	265	69.0	260	103
Total (>C5-C40) Ali/Aro	N	mg/kg	1	2510	3630	2750	817



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Results Summary

Report No.: 21-34001, issue number 1

Asbestos Results

Analytical result only applies to the sample as submitted by the client. Any comments, opinions or interpretations (marked #)
in this report are outside UKAS accreditation (Accreditation No2683). They are subjective comments only which must be verified by the client.

Elab No	Depth (m)	Clients Reference	Description of Sample Matrix #	Asbestos	Gravimetric Analysis Total	Gravimetric Analysis by ACM Type	Free Fibre Analysis	Total Asbestos
239043	0.30	WS1	Brown sandy soil, stones, road-	No asbestos detected	n/t	n/t	n/t	n/t
239044	0.50	WS2	Brown sandy soil, stones, road-	No asbestos detected	n/t	n/t	n/t	n/t
239045	0.40	WS3	Brown sandy soil, stones, road-	No asbestos detected	n/t	n/t	n/t	n/t
239046	0.50	WS4	Brown sandy soil, stones, road-	No asbestos detected	n/t	n/t	n/t	n/t

Method Summary

Report No.: 21-34001, issue number 1

Parameter	Codes	Analysis Undertaken On	Date Tested	Method Number	Technique
Soil					
Free cyanide	N	As submitted sample	03/06/2021	107	Colorimetry
Sulphide	N	As submitted sample	03/06/2021	109	Colorimetry
Hexavalent chromium	N	As submitted sample	02/06/2021	110	Colorimetry
pH	M	Air dried sample	02/06/2021	113	Electromeric
Acid Soluble Sulphate	U	Air dried sample	02/06/2021	115	Ion Chromatography
PAH (GC-FID)	M	As submitted sample	01/06/2021	133	GC-FID
Water soluble anions	M	Air dried sample	01/06/2021	172	Ion Chromatography
Low range Aliphatic hydrocarbons soil	N	As submitted sample	02/06/2021	181	GC-MS
Low range Aromatic hydrocarbons soil	N	As submitted sample	02/06/2021	181	GC-MS
BTEX in solids	M	As submitted sample	02/06/2021	181A	GC-MS
Water soluble boron	N	Air dried sample	02/06/2021	202	Colorimetry
Aliphatic hydrocarbons in soil	N	As submitted sample	01/06/2021	214	GC-FID
Aliphatic/Aromatic hydrocarbons in soil	N	As submitted sample	02/06/2021	214	GC-FID
Aromatic hydrocarbons in soil	N	As submitted sample	02/06/2021	214	GC-FID
Asbestos identification	U	Air dried sample	04/06/2021	280	Microscopy
Aqua regia extractable metals	M	Air dried sample	01/06/2021	300	ICPMS
Soil organic matter	U	Air dried sample	07/06/2021	BS1377:P3	Titrimetry

Tests marked N are not UKAS accredited

Report Information

Report No.: 21-34001, issue number 1

Key

U	hold UKAS accreditation
M	hold MCERTS and UKAS accreditation
N	do not currently hold UKAS accreditation
^	MCERTS accreditation not applicable for sample matrix
*	UKAS accreditation not applicable for sample matrix
S	Subcontracted to approved laboratory UKAS Accredited for the test
SM	Subcontracted to approved laboratory MCERTS/UKAS Accredited for the test
NS	Subcontracted to approved laboratory. UKAS accreditation is not applicable.
I/S	Insufficient Sample
U/S	Unsuitable sample
n/t	Not tested
<	means "less than"
>	means "greater than"

LOD LOD refers to limit of detection, except in the case of pH soils and pH waters where it means limit of discrimination.
Soil sample results are expressed on an air dried basis (dried at < 30°C), and are uncorrected for inert material removed.
ELAB are unable to provide an interpretation or opinion on the content of this report.
The results relate only to the sample received.
PCB congener results may include any coeluting PCBs
Uncertainty of measurement for the determinands tested are available upon request
Unless otherwise stated, sample information has been provided by the client. This may affect the validity of the results.

Deviation Codes

-
- | | |
|---|--|
| a | No date of sampling supplied |
| b | No time of sampling supplied (Waters Only) |
| c | Sample not received in appropriate containers |
| d | Sample not received in cooled condition |
| e | The container has been incorrectly filled |
| f | Sample age exceeds stability time (sampling to receipt) |
| g | Sample age exceeds stability time (sampling to analysis) |

Where a sample has a deviation code, the applicable test result may be invalid.

Sample Retention and Disposal

All soil samples will be retained for a period of one month
All water samples will be retained for 7 days following the date of the test report
Charges may apply to extended sample storage



APPENDIX F

SOIL CONTAMINATION ASSESSMENT TABLES



METALS DATA SUMMARY AND RISK ASSESSMENT SHEET

Job number: **CCG-C-21-12359**

Site name: **Great Ducie Street, Manchester**

Prepared by: **D. O'Regan**

Authorised by: **C. Bolan**

Proposed land use: **Commercial/Industrial**

SOM % used: **2.5**



= **Threshold exceeded**



= **Below Limit of detection**



= **Not tested**

			Metals							
Contaminants			Cadmium	Chromium III	Chromium VI	Copper	Lead	Mercury (elemental)	Nickel	Zinc
Units			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Limit of Detection			0.5	5.0	0.8	5.0	5.0	0.5	5.0	5.0
Human Health Risk Assessment (GAC)			190	8600	33	68000	2300	58	980	730000
Sample Location	Sample Depth (m)	Sample type								
WS1	0.30	SOIL	1.5	40.7	< 0.8	52.7	156	< 0.5	44.1	285
WS2	0.50	SOIL	1.4	35.2	< 0.8	51.9	172	< 0.5	37.3	248
WS3	0.40	SOIL	0.9	28.3	< 0.8	23.3	56.1	< 0.5	29.1	164
WS4	0.50	SOIL	0.7	25.5	< 0.8	57.7	342	0.7	26.4	202
Human Health Risk Assessment (GAC)			190	8600	33	68000	2300	58	980	730000



SEMI-METALS, NON-METALS, INORGANICS AND OTHER DATA SUMMARY AND RISK ASSESSMENT SHEET

Job number: CCG-C-21-12359

Site name: Great Ducie Street, Manchester

Prepared by: D. O'Regan

Authorised by: C. Bolan

Proposed land use: Commercial/Industrial

SOM % used: 2.5

 = Threshold exceeded

 = Below Limit of detection

n/t = Not tested

			Semi/non-metals			Inorganics			Other	
Contaminants			Arsenic	Boron	Selenium	Cyanide (free)	Sulphate (water soluble)	Sulphate (water soluble)	pH (units)	Soil Organic Matter %
Units			mg/kg	mg/kg	mg/kg	mg/kg	g/l	mg/l	units	units
Limit of Detection			1.0	0.5	1.0	1.0	0.02	20.0	0.1	0.1
Human Health Risk Assessment (GAC)			640	240000	12000	120	NA	NA	NA	NA
Sample Location	Sample Depth (m)	Sample type								
WS1	0.30	SOIL	11.2	< 0.5	< 1.0	< 1.0	0.07	n/t	8.1	5.1
WS2	0.50	SOIL	12.3	< 0.5	< 1.0	< 1.0	0.02	n/t	8.4	5
WS3	0.40	SOIL	5.9	< 0.5	< 1.0	< 1.0	< 0.02	n/t	8.6	4.9
WS4	0.50	SOIL	13.4	< 0.5	< 1.0	< 1.0	0.02	n/t	8.4	3.7
Human Health Risk Assessment (GAC)			640	240000	12000	120	NA	NA	NA	NA



SPECIATED PAH'S DATA SUMMARY AND RISK ASSESSMENT SHEET

Job number: CCG-C-21-12359

Site name: Great Ducie Street, Manchester

Prepared by: D. O'Regan

Authorised by: C. Bolan

Proposed land use: Commercial/Industrial

SOM % used: 2.5

 = Threshold exceeded

 = Below Limit of detection

 = Not tested

Contaminants

PAH's

			Acenaphthene	Acenaphthylene	Anthracene	Benz[a]anthracene	Benzo[a]pyrene	Benzo[b]fluoranthene	Benzo[ghi]perylene	Benzo[k]fluoranthene	Chrysene	Dibenzo[ah]anthracene	Fluoranthene	Fluorene	Indeno[123-cd]pyrene	Naphthalene	Phenanthrene	Pyrene	Total PAH's
Units			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Limit of Detection			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4
Human Health Risk Assessment (GAC)			97000	97000	540000	170	35	44	4000	1200	350	3.6	23000	68000	510	460	22000	54000	NA
Sample Location	Sample Depth (m)	Sample type																	
WS1	0.30	SOIL	0.3	0.1	0.5	1.8	3.2	3.1	4.2	3.1	3.4	1.5	3.2	0.2	3.8	< 0.1	1.4	3.1	32.9
WS2	0.50	SOIL	< 0.1	< 0.1	0.2	1.2	2.5	2.3	2.8	2.5	2.3	1.1	2	< 0.1	2.9	< 0.1	0.6	2.1	22.5
WS3	0.40	SOIL	0.5	< 0.1	0.7	2.6	3.5	3.6	4.6	3.6	4.1	1.2	4.6	0.3	2.4	0.1	2.5	4.4	38.7
WS4	0.50	SOIL	0.1	< 0.1	0.2	0.7	1	0.9	1.3	1	1	0.2	1.2	< 0.1	1.1	< 0.1	0.5	1.1	10.5
Human Health Risk Assessment (GAC)			97000	97000	540000	170	35	44	4000	1200	350	3.6	23000	68000	510	460	22000	54000	NA



SPECIATED TPH'S DATA SUMMARY AND RISK ASSESSMENT SHEET

Job number: CCG-C-21-12359

Site name: Great Ducie Street, Manchester

Prepared by: D. O'Regan

Authorised by: C. Bolan

Proposed land use: Commercial/Industrial

SOM % used: 2.5

	=	Threshold exceeded
	=	Below Limit of detection
n/t	=	Not tested

			Speciated TPH's															
			Aromatics							Aliphatics								
Contaminants			EC5-7	EC7-8	EC8-10	EC10-12	EC12-16	EC16-21	EC21-35	EC35-44	EC5-6	EC6-8	EC8-10	EC10-12	EC12-16	EC16-35	EC35-44	TOTAL TPH'S
Units			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Limit of Detection			0.01	0.01	1.0	1.0	1.0	1.0	1.0	1.0	0.01	0.01	1.0	1.0	1.0	1.0	1.0	1.0
Human Health Risk Assessment (GAC)			46000	110000	8100	28000	37000	28000	28000	28000	5900	17000	4800	23000	82000	1700000	1700000	NA
Sample Location	Sample Depth (m)	Sample type																
WS1	0.30	SOIL	< 0.01	< 0.01	< 1.0	< 1.0	< 1.0	13.9	829	265	< 0.01	< 0.01	< 1.0	< 1.0	2.4	883.7	516	2510
WS2	0.50	SOIL	< 0.01	< 0.01	< 1.0	< 1.0	< 1.0	6.7	171	69	< 0.01	< 0.01	3.2	5.8	26.3	2078.9	1260	3630
WS3	0.40	SOIL	< 0.01	< 0.01	< 1.0	< 1.0	< 1.0	15.4	876	260	< 0.01	< 0.01	< 1.0	< 1.0	3.9	972.6	626	2750
WS4	0.50	SOIL	< 0.01	< 0.01	< 1.0	< 1.0	< 1.0	4.3	250	103	< 0.01	< 0.01	< 1.0	< 1.0	< 1.0	255	204	817
Human Health Risk Assessment (GAC)			46000	110000	8100	28000	37000	28000	28000	28000	5900	17000	4800	23000	82000	1700000	1700000	NA



BTEX DATA SUMMARY AND RISK ASSESSMENT SHEET

Job number: **CCG-C-21-12359**

Site name: **Great Ducie Street,
Manchester**

Prepared by: **D. O'Regan**

Authorised by: **C. Bolan**

Proposed land use: **Commercial/Industrial**

SOM % used: **2.5**

 = **Threshold exceeded**

 = **Below Limit of detection**

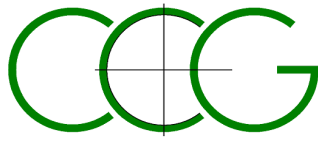
n/t = **Not tested**

			BTEX			
Contaminants			Benzene	Toluene	Ethylbenzene	Total Xylenes
Units			µg/kg	µg/kg	µg/kg	µg/kg
Limit of Detection			10	10	10	10
Human Health Risk Assessment (GAC)			95	4300	2800	NA
Sample Location	Sample Depth (m)	Sample type				
WS1	0.30	SOIL	< 10.0	< 10.0	< 10.0	< 10.0
WS2	0.50	SOIL	< 10.0	< 10.0	< 10.0	< 10.0
WS3	0.40	SOIL	< 10.0	< 10.0	< 10.0	< 10.0
WS4	0.50	SOIL	< 10.0	< 10.0	< 10.0	< 10.0
Human Health Risk Assessment (GAC)			95	4300	2800	NA



APPENDIX G

SAMPLING METHODOLOGIES



SAMPLING, SAMPLE TRANSPORTATION, AND FIELD MONITORING PROTOCOLS

Soil, water and gas sampling and monitoring methodologies employed by **CC GEOTECHNICAL LTD** are presented hereunder.

SAMPLING OF SOIL FOR CHEMICAL ANALYSIS

Soil samples may be recovered from a variety of intrusive investigation methods including *inter alia* dynamic sampling boreholes, cable percussion boreholes, machine or manual excavation of trial pits.

All equipment which has the potential to introduce extraneous materials into soils – borehole casings, sampling drilling rods, borehole sampling tools, hand tools such as trowels and spades etc. – must be cleaned by jet washing before initial use and between sampling positions.

Cable Percussion Boreholes

In this method of investigation disturbed bulk and small disturbed samples are recovered at regular depth increments throughout the length of the borehole. Each bulk/small disturbed sample is uniquely labelled with the Project Name / Project No / Borehole No / Depth / Date. Where possible, samples are immediately scanned by PID.

Light Dynamic Sampling Boreholes

In this method of investigation samples are recovered in relatively undisturbed 1m long Perspex liners. Each liner is uniquely labelled with the Project Name / Project No / Borehole No / Depth / Date. The liner tubes are sealed by air tight caps fitted at each end, and are temporarily stored out of sunlight. Where possible, samples are immediately split, scanned by PID, logged and subsampled. In the event that splitting and logging on site is not practicable, then the liners are immediately transported to the laboratory where they are immediately split, scanned by PID, logged and subsampled.

Trial Pits

Samples are to be taken from the bucket of an excavator and placed in appropriate airtight containers. Each container is uniquely labelled with the Project No / Trial Pit No / Depth / Date. The samples are then immediately placed in a cool box chilled by ice packs, and the boxes are sealed for transportation to the chemical laboratory.

Sampling Containers

Containers used to store soil samples are selected dependant on the required analysis. The testing laboratory will be consulted should there be any doubt as to the correct sampling container. Typically, a minimum of 1nr 1kg plastic tub, 1nr 500g plastic tub, 1nr 250g amber glass jar and 2nr glass vials are taken at each sample depth. Samples held on site awaiting same day courier collection are stored at 4°C in a cool box. Only in circumstances where same day collection cannot be arranged are samples held overnight, and in this event all samples are refrigerated at 4 °C either on site (if a refrigerator is available) or at CC GEOTECHNICAL soil laboratory. Courier collection is then arranged for immediate pick up the following day.

Chain of Custody records

A Chain of Custody Record (CoC) is to be sent with each batch of samples submitted to the testing laboratory. A copy of the CoC will be made available for inspection by the client, their agents, or any requesting regulatory authority.

HEADSPACE ANALYSES

Duplicate subsamples of all soil samples selected for laboratory analysis may be taken for headspace analyses.

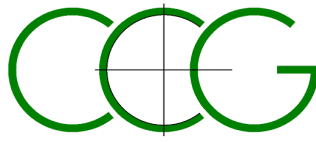
Headspace analysis is undertaken using a MiniRae 2000 Photo Ionisation Detector (PID). In the test method, an amber glass jar is half filled with soil, and the lid is sealed with aluminium foil secured by an elastic band. The jar and contents are agitated for 30 seconds and left for a minimum of 30 minutes out of direct sunlight for the headspace to achieve equilibrium. The PID then pierces the seal and the maximum reading is recorded. Prevailing weather conditions and ambient air temperature are also recorded.

The PID headspace results are recorded on the exploratory borehole or trial pit logs.

PID headspace data is then used to inform the chemical testing schedule for volatile organic compounds analyses.

SAMPLING OF GROUNDWATER FOR CHEMICAL ANALYSIS

Groundwater is sampled from standpipes or piezometers installed during borehole drilling. On completion of the construction of the standpipe, the installation is initially developed by removing up to 10 x the internal volume of the installation. The volume of water purged is recorded. The installation is then typically left for a week for hydraulic equilibrium to be restored.



Prior to sampling the standpipe, the depth to the water table, and the depth to the base of the installation are monitored using an electronic dipmeter. In circumstances where free phase product is suspected to be present, then an 'Interface Meter' is used to determine the free phase film thickness.

A minimum of 3 x the installation volume is then removed. The pH of the water is then monitored and the sample is taken when the change in pH between any two consecutive extracts is less than 10%. The volume of water removed is recorded.

A sample comprises of a minimum of 3 litres. Two litres are taken in amber glass bottles, and one litre in a plastic bottle.

To avoid cross-contamination one bailer is used per position.

The samples are uniquely labelled with Project Name / Project No / Borehole No / Depth / Date Sampled. They are placed in a cool box chilled by ice packs, and the containers are sealed for transportation to the laboratory.

Once the samples are received in the **CC GEOTECHNICAL LTD** laboratory, the samples are stored in a refrigerator and returned to the cool boxes once collected.

Water taken from the installations are taken back to the **CC GEOTECHNICAL LTD** laboratory and disposed.

Other data recorded in the sampling comprises:

- Volume of water removed during development of well
- Volume of water removed during purging of the well
- Results of on-site pH analyses
- Sample appearance – colour, suspended solids

MONITORING OF GAS

Prior to embarking on a gas-monitoring round, all equipment is checked for functionality and the calibration status is confirmed.

At the commencement of the monitoring round, the prevailing weather conditions, air temperature, barometric pressure and direction of movement of barometric pressure are recorded.

The flow meter is first attached to the standpipe valve, and the flow rate is measured (peak and steady flow) for 1 minute. The results are recorded in l.hr^{-1} . The flow meter tube is protected from the effects of wind by aligning the exhaust downwind.

Following measurement of borehole flow rate, the installation is left for a minimum of 10 minutes for the headspace to restore equilibrium.

Once the gas in the installation has regained equilibrium, the gas analyser is connected and monitoring commences. The peak and steady state readings for CH_4 , CO_2 , CO , H_2S and CO are recorded. The steady state is monitored for a minimum of one minute, and possibly up to a maximum of 10 minutes where fluctuations continue.

When the monitoring is complete, the depth to the water table, and the depth to the base of the well are monitored using an electronic dipmeter. In circumstances where free phase product is suspected to be present, then an 'Interface Meter' is used to determine the free phase film thickness.



APPENDIX H

RISK ASSESSMENT METHODOLOGY

CURRENT CONTAMINATED LAND LEGISLATION / GUIDANCE & ENVIRONMENTAL RISK ASSESSMENT

METHODOLOGY

LEGISLATION OVERVIEW

This report includes hazard identification and risk assessment in line with the risk-based methods referred to in relevant UK legislation and guidance. Government environmental policy is based upon a "suitable for use approach". When considering the current use of land, Part IIA of the Environment Protection Act 1990 (EPA 1990) provides the regulatory regime, which was introduced by Section 57 of the Environment Act 1995, which came into force in England on 1 April 2000. The main objective of introducing the Part IIA regime is to provide an improved system for the identification and remediation of land where contamination is causing unacceptable risks to human health or the wider environment given the current use and circumstances of the land.

Part IIA provides a statutory definition of contaminated land under Section 78A(2) as:

"any land which appears to the Local Authority in whose area it is situated to be in such a condition, by reason of substances in, on, or under the land, that:

- (a) Significant harm is being caused or there is a significant possibility of such harm being caused;
- or
- (b) Pollution of controlled waters is being, or is likely to be, caused."

Part IIA provides a statutory definition of the pollution of controlled waters under Section 78A(9) as:

*"the entry into controlled waters of **any** poisonous, noxious or polluting matter or **any** solid waste matter".*

In order to assist in establishing if there is a "significant possibility of significant harm" there must be a "significant pollutant linkage" for potential harm to exist. That means there must be a source(s) of contamination, sensitive receptors present and a connection or pathway between the two. This combination of source-pathway-receptor is termed a "pollutant linkage or SPR linkage."

Part IIA of The Environmental Protection Act 1990 is supported by a substantial quantity of guidance and other Regulations, especially DEFRA Circular 01/2006 Contaminated Land (this replaces DETR Circular 02/2000). Part IIA defines the duties of Local Authorities in dealing with it. With the exception of situations of very high pollution risk, Part IIA places contaminated land responsibility on the planning and redevelopment process. In situations where there is very high pollution risk direct action from the Local Authority is usually necessary. Planning Policy Statement 23 (PPS23) provides guidance on the planning process and requires that sites which have been developed shall not be capable of being determined "contaminated land" under Part IIA.

The criteria for assessing levels of pollutants and hence determining whether a site represents a hazard are based on a range of techniques, models and guidance. Within this context it is relevant to note that Government objectives are:

- (a) to identify and remove unacceptable risks to human health and the environment;
- (b) to seek to bring damaged land back into beneficial use;
- (c) to seek to ensure that the cost burdens faced by individuals, companies and society as a whole are proportionate, manageable and economically sustainable.

These three objectives underlie the "suitable for use" approach to remediation of contaminated land. The "suitable for use" approach focuses on the risks caused by land contamination. The approach recognises that the risks presented by any given level of contamination will vary greatly according to the use of the land and a wide range of other factors, such as the underlying geology of the site. Risks therefore should be assessed on a site-by-site basis.

The "suitable for use" approach then consists of three elements:

- (a) ensuring that land is suitable for its current use - in other words, identifying any land where contamination is causing unacceptable risks to human health and the environment, assessed on the basis of the current use and circumstances of the land, and returning such land to a condition where such risks no longer arise; the contaminated land regime provides the regulatory mechanisms to achieve this;
- (b) ensuring that land is made suitable for any new use, as planning permission is given for that new use - in other words, assessing the potential risks from contamination, on the basis of the proposed future use and circumstances, before official permission is given for the development and, where necessary to avoid unacceptable risks to human health and the environment, remediating the land before the new use commences; this is the role of the town and country planning and building control regimes; and
- (c) limiting requirements for remediation to the work necessary to prevent unacceptable risks to human health or the environment in relation to the current use or future use of the land for which planning permission is being sought - in other words, recognising that the risks from contaminated land can be satisfactorily assessed only in the context of specific uses of the land (whether current or proposed), and that any attempt to guess what might be needed at some time in the future for other uses is likely to result either in premature work (thereby running the risk of distorting social, economic and environmental priorities) or in unnecessary work (thereby wasting resources).

The mere presence of pollutants does not therefore necessarily warrant action, and consideration must be given to the scale of risk involved for the current and proposed end use of the site.

RISK ASSESSMENT METHODOLOGY

Current practice recommends that the determination of potential liabilities that could arise from land contamination be carried out using the process of risk assessment, whereby "risk" is defined as:

- "(a) The probability, or frequency, or occurrence of a defined hazard; and
- (b) The magnitude (including the seriousness) of the consequences."

The UK's approach to the assessment of environmental risk is set out in by the Department of the Environment (2000) publication "A Guide to Risk Assessment and Risk Management for Environmental Protection." This established an iterative, systematic staged process which comprises:

- (a) Hazard identification
- (b) Hazard assessment
- (c) Risk estimation
- (d) Risk evaluation
- (e) Risk Assessment

At each stage during the investigation process the above steps are repeated as more detailed information becomes available for the site.

CLR11- 'Model Procedures for the Management of Land Contamination', a document published by the Department for Environment, Food and Rural Affairs (DEFRA) and the Environment Agency (EA) outlines a tiered approach to the assessment of risks posed by contaminated land, as summarised hereunder:

Tier 1: Preliminary Risk Assessment

A Preliminary Risk Assessment is usually undertaken as part of a desk study, outlines potential risks posed by potential contamination to all receptors by defining plausible "pollution linkages" and developing a preliminary conceptual model (PCM). The purpose of this model is to define all possible complete pollution linkages, where the requisite source – pathway – target elements are present, and these elements being defined as:

- a contaminant (source) is a hazardous substance or agent, present at levels that have the potential to cause harm or damage a receptor
- a pathway is the means by or through which a contaminant comes into contact with, or otherwise affects, the receptor
- a receptor (target) is an entity (human being, aquatic environment, flora and fauna etc) that is vulnerable to the adverse effects of the contaminant

This relationship is termed a "pollution linkage". It should be recognised that for a health or environmental risk to exist, all three elements of the relationship or linkage must be present, i.e.

- if there is no contaminant, or contaminant present at levels below those considered to be harmful or damaging to a receptor, then there can be no adverse effect on a receptor
- if there is no receptor present that can be adversely affected by a contaminant, no harm or damage can arise
- even where both a contaminant and a receptor are present, no harm or damage will occur if there is no pathway by or through which a linkage between the two can be established

The absence of one or more of each component (source, pathway, receptor) would prevent a pollutant linkage being established and there would be no significant environmental risk.

The PCM is subject to continual refinement as additional data becomes available. As part of a Phase I Investigation (Desk Study and site walk over) a PCM is formed. Based on the PCM, potential pollutant linkages can be assessed. If the PCM and hazard assessment indicate that a pollution linkage is not of significance then no further assessment or action is required due to this linkage. For each significant and possible linkage a risk assessment is carried out. The linkages which potentially pose significant risks may require a variety of responses ranging from immediate remedial action or risk management or, more commonly, further investigation and risk assessment. This next stage is usually termed a Phase II Main Site Investigation and should provide additional data to allow refinement of the PCM and assess the level of risk from each pollutant linkage. Risk assessment will usually include Tier 2 Generic Quantitative Risk Assessment and / or, if necessary, a Tier 3 Detailed Quantitative Risk Assessment.

Tier 2: Generic Quantitative Risk Assessment (GQRA)

GQRA requires an intrusive investigation in order to characterise the site assisting in the re-assessment of the source-pathway receptor linkage. The conceptual model should be refined accordingly.

Upon completion of an intrusive investigation it must be decided whether Generic Assessment Criteria (GAC) are suitable for assessing the risk posed by observed contamination at the site. If GAC are deemed unacceptable for risk assessment purposes or cannot be developed, a Tier 3 Detailed Quantitative Risk Assessment (DQRA) is required.

If GQRA reveals that unacceptable risks are not present then no further action is required. If GQRA identifies a possibility of risk, a decision must be made whether further work is required or necessary for the purposes of risk assessment. If further risk assessment is deemed not suitable not required an Options Appraisal should be undertaken. If further risk assessment is required, the scope nature of further risk assessment must be decided – it is possible that a Tier 3 DQRA will be undertaken in this scenario.

Where the Environment Agency have published an SGV for a contaminant, this will be used in the GQRA. For contaminants where an SGV has not been published and an S4UL has been published by LQM/CIEH S4UL's, then this S4UL will be used.

Where an SGV or an S4UL is not available, and a DEFRA C4SL is available, then this C4SL will be used. In house derived GAC's will only be used for contaminants where there is no SGV or LQM S4UL or DEFRA C4SL.

DQRA is used when pollutant linkages require further assessment. DQRA is often undertaken for pollutant linkages where GAC are unavailable or inappropriate for or more conservative than the actual circumstances of the site. Site specific data is used to create Site Specific Assessment Criteria (SSAC) and enable a more accurate assessment of the risks. Further investigation may or may not be required to formulate SSAC depending on the site specific conditions and information already obtained.

NOTE: A Tier 1 Preliminary Risk Assessment is undertaken as part of a Desk Study Report and a Preliminary Conceptual Model is developed for all pollutant linkages. However, the methodologies for assessing the risks to human health, risks to controlled waters and risk posed by ground gas using quantitative techniques vary considerably, therefore GQRA and DQRA for human health, controlled waters and ground gas must be undertaken separately. The risk assessment methodologies where quantitative assessment is used for risks to human health, risks to controlled waters and risks posed by ground gas, if relevant, are described hereunder.

Background

- Environment Agency : 2008: Updated Technical Background to the CLEA model Science Report SC050021/SR3
- Environment Agency : 2008: Human Health Toxicological Assessment of Contaminants in Soil SC050021/SR2

- CL:AIRE :2008 Guidance on Comparing Data With a Critical Concentration

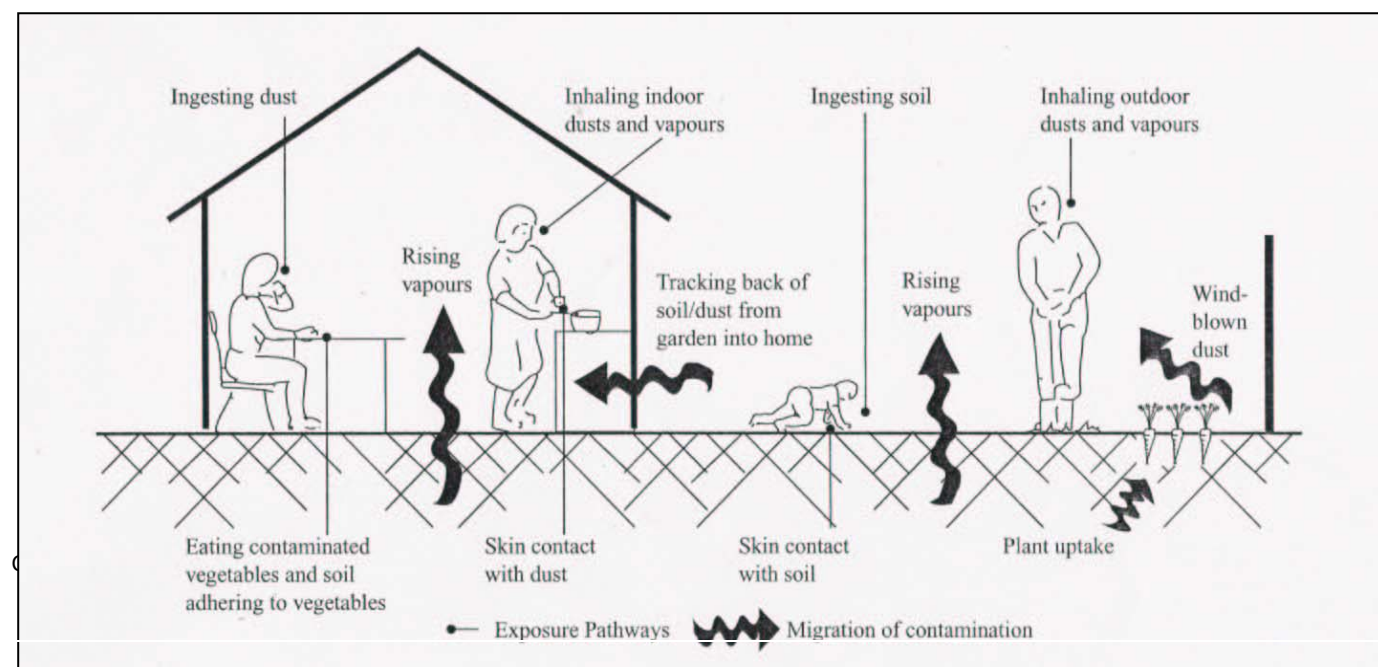
Other guidance/software used in spatial / statistical assessment is provided in:

- USEPA 2006: Data Quality Assessment: Statistical Methods for Practitioners
- Spatial Analysis and Decision Assistance (SADA) – The University of Tennessee

A different approach to the statistical appraisal of data is required depending on whether the assessment of risk is to assess whether land is Contaminated Land in accordance with regulations, or whether the assessment is to determine whether the site is suitable for new development in according with Planning guidance. This is discussed further in CL:AIRE :2008 "Guidance on Comparing Data With a Critical Concentration".

A program for the derivation of GAC`s based on the above guidance is provided by the Environment Agency and is entitled "CLEA Software Version 1.06".

The CLEA model has been developed to calculate an estimated tolerable daily soil intake (TDSI) for site users given a set of 'default' exposure pathways. Ten human exposure pathways are covered in the CLEA model as presented below:



(

Ingestion

- ingestion of outdoor soil
- ingestion of indoor dust
- ingestion of home grown produce
- ingestion of soil attached to home grown produce

Dermal Contact

- dermal contact with outdoor soil
- dermal contact with indoor dust

Inhalation

- inhalation of outdoor dust
- inhalation of indoor dust
- inhalation of outdoor soil vapour
- inhalation of indoor soil vapour

It should be noted that there are other potential exposure pathways on some sites not included in the CLEA model e.g. certain organic compounds can pass through plastic water pipes into drinking water supply.

Where contaminated water is present at a depth less than 2mbgl and there is a potential risk of inhalation of vapours (only when volatile compounds are present) the risk from inhalation of vapours from soil water will be assessed using a UK compliant version of BP Risc v4.02.

The presence and/or significance of each of the above exposure pathways are dependent on the type of land use being considered and the nature of the contaminant under scrutiny. Accordingly, the CLEA model considers for principle 'default' land use types and makes a series of 'default' assumptions with regard to human exposure frequency, duration and critical human target groups for each land use considered:

- residential
- allotments
- commercial / industrial land use

The above land use categories defined in the CLEA are detailed below:

Residential: This generic scenario assumes a typical residential property consisting of a two-storey house built on a ground-bearing slab with a private garden consisting of lawn, flowerbeds, and a small fruit and vegetable patch. The occupants are assumed to be parents with young children, who make regular use of the garden area.

Allotments: This generic scenario assumes a plot of open space (about 250 m²), commonly made available by the local authority to tenants to grow fruit and vegetables for their own consumption. There are usually several plots to a site and the overall site area may cover more than a hectare. The tenants are assumed to be parents or grandparents and that young children make occasional accompanied visits to the plot.

Commercial / Industrial: There are many different kinds of workplace and work-related activities. This generic scenario assumes a typical commercial or light industrial property consisting of a threestorey building at which employees spend most time indoors and are involved in officebased or relatively light physical work.

Human Health Risk Assessment Methodology

Assessment of risk for the protection of human health is undertaken using the methodology as outlined previously, and summarised hereunder:

- Tier 1 Preliminary Risk Assessment
- Tier 2 Generic Quantitative Risk Assessment
- Tier 3 Detailed Quantitative Risk Assessment

The Tier 1 Preliminary Risk Assessment is undertaken as part of the desk study report and includes the development of a Preliminary Conceptual Model. Tier 2 and Tier 3 Quantitative Risk Assessments are undertaken in order to develop and refine the Preliminary Conceptual Model aiding a more detailed assessment of the risk posed by contaminants revealed by site investigation and soil / soil water chemical analyses.

The methods used by **CC GEOTECHNICAL LTD** to derive assessment criteria, to statistically analyse chemical data and to compare chemical data to the derived assessment criteria are discussed herunder.

Derivation of Generic Assessment Criteria (GAC) and Site Specific Assessment Criteria (SSAC)

GAC's are derived on the basis of the proposed land use and the associated applicable exposure pathways. It should be noted that there are difficulties in establishing soil concentrations of contaminants beyond which risks from exposure to these contaminants would be 'unacceptable' and the GAC value does not necessarily equate to the level for "significant possibility of significant harm" as defined in Part IIA of The Environmental Protection Act (1990) to determine whether land is "contaminated." This ultimately requires detailed 'toxicological' information of the health effects of individual contaminants and also a scientific judgement on what constitutes an 'unacceptable' risk. The primary purpose of the CLEA derived GAC's are as 'minimal risk thresholds' for the assessment of human health risks in relation to land use.

Minimal risk thresholds calculated using generic input parameters for each of the above land uses are termed Generic Assessment Criteria (GAC) and are used for Generic Quantitative Risk Assessment (GQRA). However, further assessment may be required taking into consideration site specific factors such as the way the land is used, the soil type, the building

characteristics and the exact nature of the receptor, to determine whether there is a significant possibility of risk to human health to site users. Such an assessment is known as a Detailed Quantitative Risk Assessment (DQRA) and the resultant threshold concentrations are known as Site Specific Assessment Criteria (SSAC). Such assessments should be conducted with the agreement of the local authority (or the Environment Agency) since it is the authority that determines whether land is Contaminated Land or whether Planning Permission for a new development may be granted.

For the purposes of this report, assessment criteria have been derived in accordance with current guidance based on the conceptual model for the proposed land use using the CLEA v1.06 software. These criteria are not intended to indicate whether the site may be contaminated land nor do they replace any published soil guideline values. However, the values are intended to provide guidance for the local authority on whether the site may be considered uncontaminated. If, based on the site's proposed future use, the site would be considered by the local authority to be uncontaminated and therefore, on the basis of soil concentrations, fit for purpose, then no further risk assessment based on soil concentrations and the risk to human health would be necessary. However, should these criteria be exceeded or the conceptual site model vary from the model used in the risk assessment to derive these values then the risk assessment should be updated accordingly.

For contaminants routinely analysed where inhalation is a significant pathway (naphthalene, phenanthrene, Aromatic EC5-EC7, Aromatic EC7-EC8, Aromatic EC8-EC10, Aromatic EC10-EC12, Aromatic EC12-EC16, Aliphatic EC5-EC6, Aliphatic EC8-EC10, Aliphatic EC10-EC12, Aliphatic EC12-EC16), plots of the GAC as a function of Soil Organic Matter (SOM) are used to determine if they pose a potential risk to human health, which are presented hereunder. Where there is an exceedance further assessment may be undertaken.

Statistical Assessment of Soil Contamination Data & Comparison of Contamination Data to Threshold Values

In any site investigation only a small fraction of the soil on the site is analysed. Therefore the mean derived from the contamination data for a contaminant may not be the same as the true mean for the contaminant distribution on the site. To improve the reliability of any assessment a statistical analysis is undertaken in line with the CL:AIRE document "Guidance on Comparing Soil Contamination Data with a Critical Concentration".

Statistical assessment of soil data is undertaken using programs based on the guidance in the CL:AIRE document or the USEPA software ProUCL v4.0.

Where the number of results in a dataset is less than four, a statistical assessment is not undertaken, and the assessment is performed by comparison of the maximum value(s) with a Health Criteria Value (HCV), such as Generic Assessment Criteria value(s).

For the Planning situation, the regulator needs to check whether the concentration of contaminants is low compared to the HCV. This decision is based on whether there is at least a 95% confidence level that the true mean of the dataset is lower than the HCV.

For the Part IIA scenario the regulator needs to determine whether the concentration of contaminants is greater than the HCV. This decision is based on whether there is at least a 95% confidence level that the true mean of the dataset is higher than the HCV. However, the regulator may proceed with determination if there is just a 51% probability, "on the balance of probabilities".

The Outlier Test used in the statistical assessment may not be able to identify separate populations if numerous populations are present. In order to ensure that this is not the case a spatial assessment of the data will be undertaken using SADA.

If the screening levels are exceeded then more sophisticated quantitative risk assessment or remedial action may be undertaken. The benefits of undertaking a quantitative risk assessment must be weighed against the likelihood that it will bring about cost savings in the proposed remediation.

BACKGROUND INFORMATION, CURRENT GUIDANCE AND RISK ASSESSMENT METHODOLOGY FOR RISKS POSED TO CONTROLLED WATER

Definition of Controlled Waters

The term 'controlled waters' is defined in Section 104 of the Water Resources Act 1991 as:

"Territorial Waters...which extend seawards for three miles..., coastal waters..., inland freshwaters, waters in any relevant lake or pond or of so much of any relevant river or watercourse as is above the freshwater limit, and ground waters, that is to say, any waters contained in underground strata."

Note that the definition of groundwater under the Water Resources Act 1991 includes all water within underground strata (including soil / pore water in the unsaturated zone). The definition of groundwater under the Groundwater Directive however is limited to water in the saturated zone. For the purposes of Part IIA of the Environmental Protection Act 1990, the Environment Agency recommends that the groundwater within the saturated zone only is considered as the receptor (rather than soil / pore water).

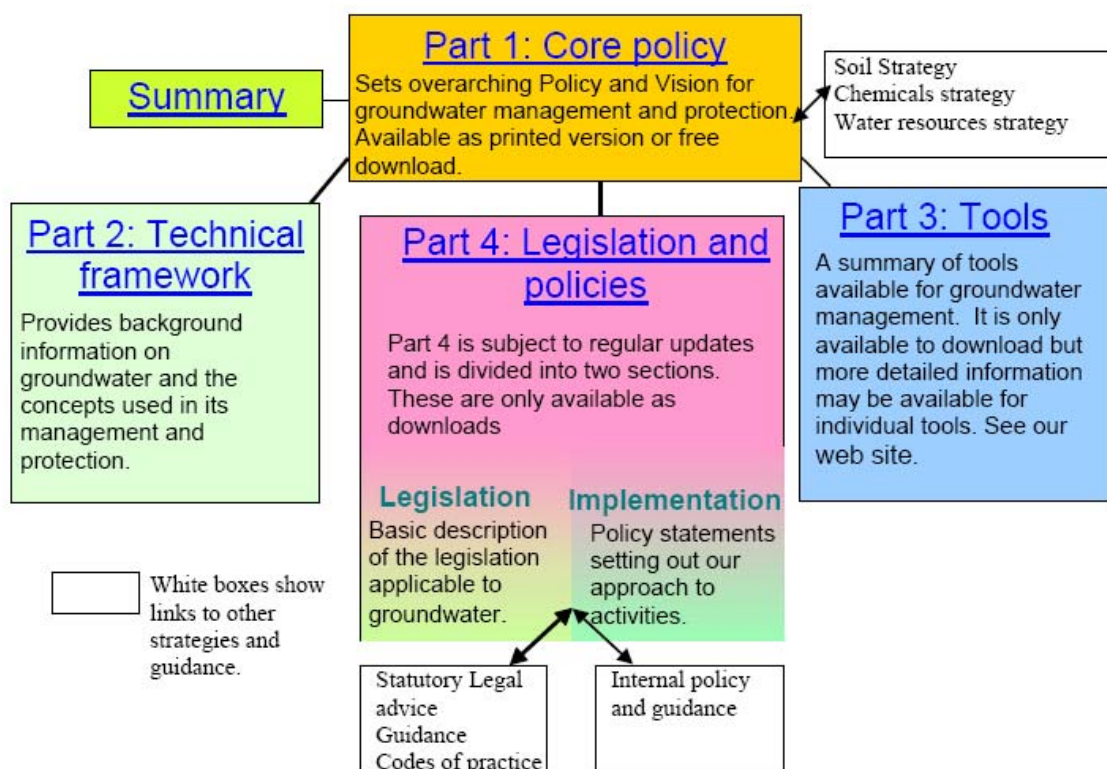
Environment Agency Guidance

Legislation and guidance surrounding the protection of controlled waters in the UK is abundant and can be complex. The Environment Agency's overall position on groundwater is *"To protect and manage groundwater resources for present and future generation in ways that are appropriate for the risks that we identify"* (Groundwater Protection : Policy and Practice GP3, 2006). In brief, the core objectives of the existing legislation serve to enforce this position.

In 1992, the National Rivers Authority published their Policy and Practice for the Protection of Groundwater (PPPG), this document was influential as it provided a focus for key developments such as Source Protection Zones (SPZs) and

Groundwater Vulnerability Maps. The Policy was then revised in 1998, since which there have been substantial changes in legislation, driven by Europe. Key European Directives relating to groundwater include the Groundwater Directive (80/68/EEC) and the Water Framework Directive (2000/60/EC). Aspects of these directives are controlled by primary UK legislation such as the Water Resources Act 1991. Further to legislative changes, gaps identified in the 1998 PPPG required addressing. These changes are reflected in the forthcoming Environment Agency Policy document entitled *Groundwater Protection : Policy and Practice (GP3)*, a draft version of which was available for public consultation (Parts 1 to 3) ending July 2006 with Part 4 issued in March 2008. Part 4 includes a section on key groundwater legislation and the Environment Agency's interpretation of it.

The following gives a breakdown of the structure of the document (taken from the Environment Agency GP3 draft consultation document, 2006)



Controlled Water Risk Assessment Methodology

The risk posed to controlled water is assessed by **CC GEOTECHNICAL** in accordance with current guidance as outlined hereunder.

In order for a developer of a potentially contaminated site to fulfil their obligations under the legislation, a site assessment would be required to be undertaken in order to identify any potential risks to controlled waters and to derive suitable clean-up criteria if necessary to ensure the protection of controlled waters. The general approach for Groundwater Protection is detailed further in Part 3 of GP3.

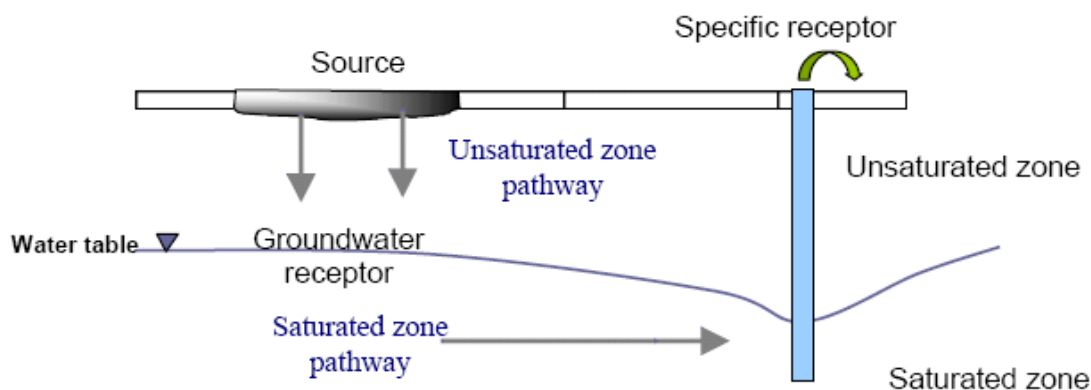
When assessing groundwater impact the Environment Agency advocate the application of their framework methodology "Remedial Targets Methodology – Hydrogeological Risk Assessment for Land Contamination" Environment Agency (2006). The methodology has four levels of assessment as described below:

- **Level 1** considers whether contaminant concentrations in "pore water" in contaminated soil are sufficient to impact on the receptor, ignoring dilution, dispersion and attenuation along the pathway. The "pore water" concentration is determined from:
 - i) measured "pore water" concentrations or perched water quality
 - ii) soil leaching tests
 - iii) theoretical calculations based on soil/water partitioning equations
- **Level 2** considers dilution by the receiving groundwater or surface water body and whether this is sufficient to reduce contaminant concentrations to acceptable levels. The remedial target is defined as the target concentration multiplied by a dilution factor (DF).
- **Levels 3 and 4** consider whether natural attenuation (including dispersion, retardation and degradation) of the contaminant as it moves through the unsaturated and saturated zones to the receptor are sufficient to reduce contaminant concentrations to acceptable levels. The remedial target is defined as target concentration multiplied by a dilution factor (DF) and attenuation factor (AF). In **Level 3** simple analytical models are used to calculate the significance of attenuation. The Environment Agency has released a "Remedial targets worksheet v3.1" to carry out basic calculations using a conservative approach up to **Level 3** using basic principles assuming a simple migration of contaminants from the

source zone into the aquifer receptor. **Level 4** assessment uses more sophisticated numerical models, and allows for the introduction of additional geological horizons and is used mainly to determine whether soil contaminants will reach their target within a specified timeframe. Use of such software should only be used once agreement has been obtained from the Environment Agency.

Three main stages apply to any risk assessment of controlled waters, these are:

- 1. Risk Screening (Tier 1 Preliminary Risk Assessment):** The understanding of the Conceptual Site Model (CSM) is the key to assessing any site. Using a robust CSM, potential pathways or receptors may be screened out from any further assessment at an early stage. For example if the pathway through the unsaturated zone is blocked by the presence of a significant thickness of low permeability clay. A greater understanding of the CSM is achieved with each tier of risk assessment. An example of a basic CSM is given below (taken from the Environment Agency GP3 draft consultation document, 2006):



- 2. Generic Hydrogeological Risk Assessment (EA Remedial Targets Methodology Level 1):** When undertaking the Generic Hydrogeological Risk Assessment (EA Remedial Targets Methodology Tier 1), comparison of chemical analytical results is made with screening criteria. Published values of screening criteria with which chemical test results can be compared are published in the following guidance:

- Water Supply (Water Quality) Regulations 2000
- The Private Water Supplies Regulations 1991
- Environmental Quality Standards for surface waters based on The EC Dangerous Substances Directive (76/464/EEC and Daughter Directives)
- The Surface Waters (Abstraction for Drinking Water Classification) Regulations 1996
- World Health Organisation Drinking Water Standards 2004

Should the Level 1 assessment indicate threshold levels to be exceeded, then there are three alternative ways in which to proceed:

- To devise suitable remedial solutions
- To carry out more investigation, sampling and analysis
- To conduct a site specific Detailed Quantitative Risk Assessment (DQRA) to determine if the materials are suitable for their proposed use, or devise site specific clean-up level

- 3. Detailed Quantitative Risk Assessment (EA Remedial Targets Methodology Levels 2 to 4):** The decision to carry out a DQRA will be dependant on the extent and implications of the initial qualitative and generic assessment. The scope of any such assessment will be accurately defined by the outcomes of the previous levels of assessment. The conceptual model will be sufficiently refined by this stage that only certain contaminants of concern, certain pathways and certain receptors will require further assessment, the remainder having been screened out.

Additional site specific data is normally required for this stage of assessment, as explained above, more processes that are capable of affecting contaminant concentrations are considered (such as dilution and attenuation).

Remediation criteria, if derived, will therefore be specific to each site and will be based on a detailed assessment of the potential impact at the identified receptor or *compliance point*. A greater level of confidence can be placed on the predicted impact on the compliance point following a DQRA.

BACKGROUND INFORMATION, CURRENT GUIDANCE AND RISK ASSESSMENT METHODOLOGY FOR RISKS POSED BY GROUND GAS

Background

Origin of Ground and Landfill Gases

When carrying out a ground gas risk assessment, the origin or source of the gases is important as potential risks will vary depending on the source. This Appendix relates to the risk of the two main ground gases of concern; methane and carbon dioxide, and does not apply to other ground gases (e.g. radon or vapours from hydrocarbon spills). Methane and carbon dioxide are major constituents of landfill gas but can also occur from a variety of anthropogenic and natural sources, as summarised in Table 5 below:

Gas	Source	Comments
Landfill Gas	Anaerobic decomposition of degradable waste within landfill sites. Typically 60% methane and 40% carbon dioxide during methanogenic phase.	Composition varies over time, particularly in early stages. Contains a range of minor constituents (particularly carbon monoxide and hydrogen sulphide).
Landfill Associated Gases	- Anaerobic degradation of leachate external to the site; - Degassing of dissolved gases in groundwater; - Evolution of gases following interaction between leachate and groundwater	Can result in secondary (external) production of methane or carbon dioxide.
Made Ground	Anaerobic degradation of organic components	Very variable depending on source
Sewer Gas, Cess Pits	Anaerobic degradation of organic components of sewage producing methane and carbon dioxide.	Often characterised by hydrogen sulphide odour.
Mains Gas	Leakage from underground pipework or storage tanks. Mainly methane but often contains higher alkanes.	An odouriser is added to permit detection of leaks. Typically 90% CH ₄ , but 1 to 27% C ₂ -C ₄ alkanes, May also contain other trace gases e.g. CO, helium and CO ₂ (from degradation of CH ₄ in the ground).
Other Anthropogenic Sources	- Degradation of leaked or spilled hydrocarbons or other industrial chemicals; - Anaerobic degradation of organic contaminants in groundwaters (e.g. silage liquor); - Reactions between monitoring well construction components and environment; - Burial grounds/cemeteries.	Hydrocarbon spillages often have an 'oily' odour. Fuel spillages common – Petrol or Diesel and can contain a wide range of VOC's. Can degrade to produce methane / carbon dioxide.
Alluvium / Marsh / Peat Gas	Anaerobic microbial degradation of organic material (usually waterlogged vegetation / peat). Often associated with the presence of alluvial deposits or dredgings.	
Geogenic Gas	Natural seepages of carbon dioxide and hydrocarbon gases derived from geologic sources such as coal seams and deep oil / gas source formations. Can be present in solution in groundwaters.	Methane most common but can contain carbon dioxide and higher alkanes.
Mine Gases	Various types. Most common is "fire damp" with high methane, produced by the desorption of gas trapped in coal. "Black damp" (Stythe gas) with high carbon dioxide and denser than air. "White damp" is high in carbon monoxide.	Methane most common. Can contain higher alkanes, carbon dioxide and carbon monoxide. Often low in oxygen.
Natural Shallow Ground Gas	Various types - high carbon dioxide formed by subsurface aerobic activity leading to depleted oxygen and elevated carbon dioxide; - chemical degradation of rocks (e.g. carbonates) producing carbon dioxide; - carbon dioxide production in root zone of soils by plants.	Gases can be emitted from ground under falling barometric pressure conditions.

Table 5. Potential Sources of Ground Gases

This Appendix does not provide guidance for the assessment of risk when other gases are present due to 'Other Sources' from the above table (particularly organic compounds such as BTEX and VOC's or for the risk from radon or hydrogen sulphide).

To determine the origin of the gas a range of factors must be considered together, including;

1. Proximity of likely sources
2. Ground conditions (geology, hydrogeology, anthropogenic pathways etc)
3. Properties of gases present including:
 - Chemical composition
 - Physical properties
 - Ratios of components e.g. methane : carbon dioxide
4. Timeframe of activities such as infilling periods, capping works, installation of gas control systems etc

Identification of the originating source may be problematic given that there may be more than one source present and trace gas analysis may be required. Identification of the sources of the gases encountered during monitoring is usually carried out through a process of eliminating the most unlikely potential sources (given the site setting) and selecting those which are most likely.

Hazards Associated with Presence of Methane

Methane gas is combustible and potentially explosive. When the concentration of methane in air is between the limits of 5.0%v/v and 15.0%v/v an explosive mixture is formed. The Lower Explosive Limit (LEL) of methane is 5.0%v/v, which is equivalent to 100% LEL. The 15.0%v/v limit is known as the Upper Explosive Limit (UEL), but concentrations above this level cannot be assumed to represent safe concentrations. Further, the LEL and UEL will vary (up and down) depending upon the proportion of other gases (including oxygen). However, the fact that methane is a colourless, odourless gas means that there

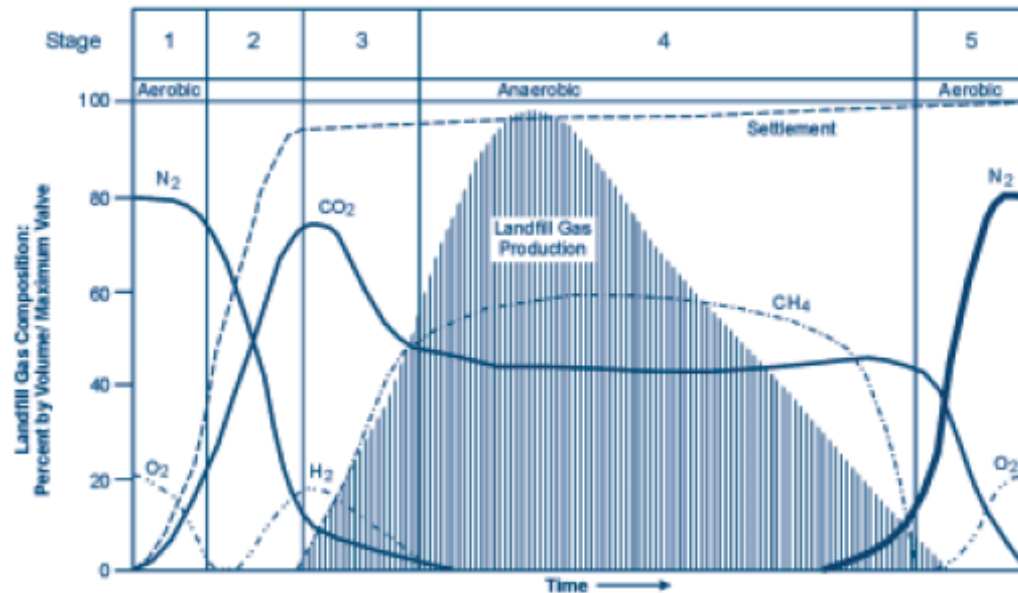
is no simple indicator of the presence of the gas until such a time as explosive limits are reached and an incident occurs. Methane is lighter than air and has a low toxicity. However, at high concentrations it can result in asphyxiation due to oxygen displacement.

Hazards Associated with Presence of Carbon Dioxide

Carbon dioxide is a colourless, odourless gas, which, although non-flammable, is both toxic and an asphyxiant. As carbon dioxide is denser than air, it will collect in low points and depressions. The UK Health & Safety Executive (HSE) has published information relating to concentrations of carbon dioxide that humans may be exposed to, which uses concentrations contained in the Control of Substances Hazardous to Health Regulations 2002 (as amended). These are the Long Term Occupational Exposure Limit (LTOEL, 8 hour period) and the Short Term Occupational Exposure Limit (STOEL, 15 minute period), which are 0.5% and 1.5% carbon dioxide, respectively.

Parameters Influencing the Rate of Ground Gas Production

The figure below is taken from EA guidance document LFTGN 03 illustrates typical ground gas generation curves from biodegradable materials:



The production of methane and carbon dioxide at a landfill site may be expected to be considerable and ongoing. Concentrations of methane will eventually decrease, followed by concentrations of carbon dioxide, but the duration and rate of gas production can vary markedly between sites. Five distinct phases of gas production occur during the process which are, in order of event as marked above, as follows:

1. An aerobic phase involving oxygen depletion and temperature increase through aerobic respiration;
2. The establishment of anaerobic conditions and the evolution of carbon dioxide and hydrogen through acidogenic activity;
3. Commencement of methanogenic activity; the establishment of populations of methanogenic bacteria;
4. A phase of stable methanogenic activity, which may go on for many tens of years;
5. A phase of decreasing methanogenic activity, representing depletion of the organic material and a return to aerobic conditions.

The time scale for the return to the normal ground gas concentrations will be highly variable, depending upon the types and quantities of materials present. In addition, the optimum parameters influencing the rate of decomposition and ground gas production within the ground at a site are as follows:

- High water content with adequate rainfall and water infiltration to provide moisture content between approximately 20 to 26%;
- Conditions that either are or are very close to anaerobic;
- High proportion of biodegradable materials;
- A pH between 6.5 and 8.5, ideally verging slightly on the acidic between pH 6 to 7;
- Temperature between 25°C and 55°C;
- The ratio of the biochemical and chemical oxygen demands (BOD:COD);
- High permeability;
- Small particle size, as finer subsurface materials possess a greater surface area to provide a growing 'face' for the micro-organisms but high fines levels reduces permeability and reduces decomposition rate.

For this reason, it is vital that sources of methane and carbon dioxide are identified prior to the commencement of any work on a construction site, and that the ground gas regime is characterised at the worst temporal conditions a site may experience. From this, a risk assessment is carried out to identify the risk at the site from ground gases so that suitable protection measures can be designed and incorporated into a development to prevent a dangerous build-up of gas occurring.

Factors Influencing the Migration and Behaviour of Ground Gases

There are many factors that influence the migration of ground gases which can effect the risk from a gassing source:

- driving force – pressure differential along a pathway, diffusion and dissolved in solution;
- meteorological conditions – short term and seasonal conditions including atmospheric pressure changes (e.g. rapidly falling pressure causes gas to expand increasing emission rates), rainfall, frozen ground and thawing, temperature;
- geological and groundwater conditions – these can have the over riding influence on the direction/pathways and quantity of migrating gas;
- anthropogenic influences – man-made pathways include mine shafts, service runs/drains, foundation piles, underground voids/pits/basements, foundation/building design/construction

Current Guidance

Previous versions of Building Regulations Approved Document C provided statutory guidance stating that consideration should be given to appropriate action and / or specific solutions in situations where methane concentration exceeded 1%v/v or carbon dioxide concentrations exceeded 5%v/v. The latest Building Regulations Approved Document C (DoE 2004) no longer endorses this approach and recommends the use of a risk based approach to interpreting a gas monitoring survey. This is in line with current EA guidance for landfill gas (LFTGN 03, 2004) which recommends the use of a structured risk based approach similar to that outlined in CLR 11. On this basis, recent guidance has been produced in 2006 and 2007 with the aim of providing up to date advice in relation to residential and commercial development. The guidance does not address issues associated with gas derived from landfills, for this refer to “*Guidance on the Management of Landfill Gas*” (Environment Agency 2004) for an overview.

Recent guidance relevant to gas assessments for residential and commercial development includes;

- **Wilson et al. (CIRIA C665, December 2007) “Assessing Risks Posed by Hazardous Ground Gases for Buildings.”**
This document provides up to date advice on all aspects of ground gas risk assessment such as investigation, monitoring programmes, data collection and interpretation. The guidance presents separate methodologies for the characterisation of:
 - All development types except low rise housing with gardens (Situation A)
 - Low rise housing with gardens (Situation B)
- **Boyle and Witherington (NHBC / RSK Group, Report 10627-R01(04) January 2007) “Guidance on the Evaluation of Development Proposals on Sites where Methane and Carbon Dioxide are Present.”**
This document presents the “Traffic Lights System” detailed below and is relevant only for low rise properties (e.g. bungalows and town houses) that have a ventilated sub-floor void (i.e. Situation B as described in CIRIA C665).
- **British Standard (BS 8485 2015) “Code of Practice for the Characterization and Remediation from Ground Gas in Affected Developments”**
This document provides an overview of gas characterisation and assessment. The Standard is intended to be used by designers of gas protection measures and regulators involved in the assessment of design solutions.

Further guidance, **Wilson and Card (CIEH) “Ground Gas Handbook for Designers and Regulators”** providing practical guidance on ground gas assessments and the design and evaluation of protection measures, is expected to be published in March 2009.

Each of these documents continues to highlight the importance of, and give further guidance towards, carrying out a tiered risk-based decision-making process in accord with government policy on dealing with contamination from historic or natural sources and highlight the importance of the Conceptual Model in site characterisation.

Ground Gas Risk Assessment Methodology

Assessment of risk posed by ground gas is undertaken using the methodology as outlined previously, and summarised hereunder:

- Tier 1 Preliminary Risk Assessment
- Tier 2 Generic Quantitative Risk Assessment
- Tier 3 Detailed Quantitative Risk Assessment

The methodology used in each of the above assessments with concern to ground gas is discussed hereunder.

Tier 1 Preliminary Risk Assessment

All potential sources of methane and carbon dioxide are identified in the Preliminary Conceptual Model and the generation potential determined. The background information discussed earlier is referred to in order to determine the potential for a source to generate ground gas.

CIRIA C665 provides idealised monitoring frequency / period dependant upon generation potential of gas source and sensitivity of the proposed land use as below:

Idealised Frequency and Period of Monitoring (after Table 5.5a and 5.5b, CIRIA C665)

		Generation Potential of Source				
		Very Low	Low	Moderate	High	Very High
Sensitivity of Development	Low (Commercial)	4/1	6/2	6/3	12/6	12/12
	Moderate (Flats)	6/2	6/3	9/6	12/12	24/24
	High (Residential with Gardens)	6/3	9/6	12/6	24/12	24/24

Notes

1. First number is the number of readings and the second is the minimum period in months (e.g. 6/2 – six sets of readings over two months).
2. At least two sets of readings must be at low (preferably under 1,000 mb) and falling pressure.

The monitoring programme is decided using the above table prior to the intrusive site investigation. However, if the intrusive investigation reveals that a the potential source is better or worse than anticipated the monitoring programme should be modified accordingly. For example, if the made ground contains no evidence of organic material and comprises entirely granular brick fill, the potential for that made ground to generate ground gas is reduced considerably.

Tier 2 Generic Quantitative Risk Assessment

Generic Quantitative Risk Assessment is undertaken upon completion of the required gas monitoring period.

All three current guidance documents propose that both ground gas concentrations and flow rates are used to calculate the limiting gas well gas volume flow rates for methane and carbon dioxide, based on the ground gas conditions monitored for during the worse-case temporal conditions. This limiting gas well volume flow rate is termed the Gas Screening Value (GSV, note that this was termed borehole gas volume flow), and is calculated as follows:

$$\text{GSV (l/hr)} = \frac{[\text{gas well gas concentration (\%v/v)}] \times [\text{gas well flow rate (l/hr)}]}{100}$$

GSV's are compared to typical max concentrations and limiting gas screening values derived for either Situation A - All development except low rise housing with gardens, or Situation B low rise housing with gardens (NHBC Traffic Light System). Table 8.5 from CIRIA C665 is used for comparison of gas screening values for "Situation A Developments" and is presented hereunder:

Characteristic Situation (CIRIA R149)	Comparable Partners in Technology gas Regime (see Box 8.2)	Risk Classification	Gas Screening Value (CH ₄ or CO ₂) (l/hr) ¹	Additional Factors	Typical Source of Generation
1	A	Very low risk	<0.07	Typically methane ≤ 1% and/or carbon dioxide ≤ 5%. Otherwise consider increase to Situation 2	Natural soils with low organic content "Typical" made ground
2	B	Low risk	<0.7	Borehole air flow rate not to exceed 70l/hr. Otherwise consider increase to characteristic Situation 3	Natural soil, high peat/organic content. "Typical" made ground
3	C	Moderate risk	<3.5		Old landfill, inert waste, mineworking flooded
4	D	Moderate to high risk	<15	Quantitative risk assessment required to evaluate scope of protective measures.	Mineworking susceptible to flooding, completed landfill (WMP 26B criteria)
5	E	High risk	<70		Mineworking unflooded inactive with shallow workings near surface
6	F	Very high risk	>70		Recent landfill site

Table 8.5 from CIRIA C665 Modified Wilson and Card Classification

Table 8.7 is used for comparison of gas screening values for "Situation B Developments" and is presented herunder:

Traffic Light	Methane ¹		Carbon Dioxide ²	
	Typical max concentration ³ (% by volume)	Gas screening value ^{2,4} (litres / hour)	Typical max concentration ³ (% by volume)	Gas screening value ^{2,4} (litres / hour)
Green				
Amber 1	1	0.13	5	0.78
Amber 2	5	0.63	10	1.60
Red	20	1.60	30	3.10

Notes:

1. The worst-case ground gas regime identified on the site, either methane or carbon dioxide, at the worst-case temporal conditions that the site may be expected to encounter will be the decoder as to what Traffic Light is allocated;
2. Borehole Gas Volume Flow Rate, in litres per hour as defined in Wilson and Card (1999), is the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered;
3. The Typical Maximum Concentration can be exceeded in certain circumstances should the Conceptual Site Model indicate it is safe to do so;
4. The Gas Screening Value thresholds should not generally be exceeded without the completion of a detailed ground gas risk assessment taking into account site-specific conditions.

Table 8.7 from CIRIA C665 - NHBC Traffic light system for 150 mm void

Dependant on the outcome of the assessment of risk posed by ground gas it is determined whether gas protection measures are required for the proposed development, and or whether a detailed quantitative risk assessment is required for the site.

Selection & Design of Protective Measures

Table 8.6 and Box 8.4 of CIRIA C665 contain information on the detailed design of protection measures and were initially intended for the purposes of determining then level of protection measures a development requires. These tables and related text include some useful information on the design of gas protection measures, however BS84845:2007, which supersedes the guidance included within CIRIA C665, is used for selection of gas protection measures.

BS8485:2015 uses a scoring system dependant on the Characteristic Situation / NHBC Traffic Light and proposed end use of the site. The scoring system is summarised in BS8485:2015 Table 2 as presented hereunder:

Characteristic gas situation, CS	NHBC traffic light	Required gas protection			
		Non-managed property e.g. private housing	Public building (a)	Commercial buildings	Industrial buildings (b)
1	Green	0	0	0	0
2	Amber 1	3	3	2	1 (c)
3	Amber 2	4	3	2	2
4	Red	6 (d)	5(d)	4	3
5			6(e)	5	4
6				7	6

NOTE Traffic light indications are taken from NHBC Report no.:10627-RO1 (04) and are mainly applicable to low-rise residential housing¹. These are for comparative purposes but the boundaries between the traffic light indications and CS values do not coincide.

a) Public buildings include, for example, managed apartments, schools and hospitals.
b) Industrial buildings are generally open and well ventilated. However, areas such as office pods might require a separate assessment and may be classified as commercial buildings and require a different scope of gas protection to the main building.
c) Maximum methane concentration 20% otherwise consider and increase to CS3.
d) Residential building on higher traffic light/CS sites is not recommended unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g. high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g. in institutional and/or fully serviced contractual situations.
e) Consideration of issues such as ease of evacuation and how false alarms will be handled are needed when completing the design specification of any gas protection scheme

¹ The NHBC guidance and CIRIA C665 guidance refers to low rise housing (which is up to three storeys without lifts) that is constructed with a 150mm ventilated sub-floor void.

BS8485:2015 Table 2 Required gas protection by characteristic gas situation and type of building

Once a score is assigned, a combination of protection systems / elements is chosen from BS8485:2007 Table 3 shown below:
CD37d

PROTECTION ELEMENT / SYSTEM		SCORE	COMMENTS
a) Venting / dilution (See Annex A BS8485)			
Passive sub floor ventilation (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc.) ^A	Very good performance	2.5	Ventilation performance in accordance with Annex A (BS8485)
	Good performance	1	If passive ventilation is poor this is generally unacceptable and some form of active system will be required.
		2.5	There have to be robust management systems in place to ensure the continued maintenance of any ventilation system. Active ventilation can always be designed to meet good performance.
Subfloor ventilation with active abstraction/pressurization (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc.) ^A		2.5	Active ventilation can always be designed to meet good performance.
Ventilated car park (basement or undercroft)		4	Mechanically assisted systems come in two forms: extraction and positive pressurization.
b) Barriers			
Floor slabs			
Block and beam floor slab		0	It is good practice to install ventilation in all foundation systems to effect pressure relief as a minimum. Breaches in floor slabs such as joints have to be effectively sealed against gas ingress in order to maintain these performances.
Reinforced concrete ground bearing slab		0.5	
Reinforced concrete ground bearing foundation raft with limited service penetrations that are cast into slab		1.5	
Reinforced concrete cast in situ suspended floor slab with minimal service penetrations and water bars around all slab penetrations and at joints		1.5	
Fully tanked basement		2	
c) Membranes			
Taped and sealed membrane to reasonable levels of workmanship/in line with current good practice with validation ^{B,C}		0.5	The performance of membranes is heavily dependent on the quality of design of the installation, resistance to damage after installation, and the integrity of joints.
Proprietary gas resistant membrane to reasonable levels of workmanship /in line with good practice under independent inspection (CQA) ^{B,C}		1	
Proprietary gas resistant membrane installed to reasonable levels of workmanship/in line with current good practice under CQA with integrity testing and independent validation		2	
d) Monitoring and detection (not applicable to non-managed property, or in isolation)			
Intermittent monitoring using hand held equipment		0.5	Where fitted, permanent monitoring systems ought to be installed in the underfloor venting/dilution system in the first instance but can also be provided within the occupied space as a fail safe.
Permanent monitoring and alarm system ^A	Installed in the underfloor venting/dilution system	2	
	Installed in the building	1	
e) Pathway Intervention			
Pathway intervention		-	This can consist of site protection measures for off-site or on-site sources (see Annex A, BS8485)
NOTE In practice the choice of materials might well rely on factors such as construction method and the risk of damage after installation. It is important to ensure that the chosen combination gives an appropriate level of protection			
A)	It is possible to test ventilation systems by installing monitoring probes for post installation validation.		
B)	If a 1 200g DPM material is to function as a gas barrier it should be installed according to BRE 212 /BRE 414 being taped and sealed to all penetrations		
C)	Polymeric Materials> 1200 g (proportional to thickness) but their physical properties mean that they are more robust and resistant to damage.		

BS8485:2015 Table 3 Solution Scores

Where the gas situation is 4 or more (and for NHBC Red situations) the site requires a comprehensive risk assessment to confirm the scope of protection measures. These are higher risk sites and reliance on Table 2 and 3 alone is not sufficient.

For a site which is impacted by migratory gases from an off site source, the development may be protected by imposing pathway intervention methods, which if successfully validated, could also remove the need for further analysis. It is essential that the gas regime in these circumstances has been fully characterised and that the only source impacting the site is located off site and that the pathway is clearly defined and its interception equally proven before construction commences. Pathway intervention methods may include vertical membrane installations, venting trenches, rows of stone columns, activated trenches and various proprietary systems. These systems are particularly relevant to domestic housing where there is limited scope for foundation type solutions.

CURRENT GUIDANCE ON REMEDIATION

When risk assessment of the site has been completed and it indicates that remedial works are required, the main guidance in managing this process is set out in the DEFRA/EA publication CLR11 (2004) "Model Procedures for the Management of Land Contamination." The stages of managing remediation are as follows:

- (a) Options Appraisal and develop Remediation Strategy;
- (b) Develop Implementation Plan and Verification Plan;
- (c) Remediation, Verification and Monitoring.

The Remediation Strategy sets out the remediation targets, identifies technically feasible remedial solutions and presents an evaluation of the options so that these can be assessed enabling that the most suitable solution is adopted. An outline of the proposed remedial method should be presented. Agreement should be sought of the appropriate statutory bodies for the Remediation Strategy before proceeding to the next stage.

The Implementation Plan is a detailed method statement setting out how the remediation is to be carried out including stating how the site will be managed, welfare procedures, health and safety considerations together with practical measures such as details of temporary works, programme of works, waste management licences and regulatory consents required. Agreement should again be sought of the appropriate statutory bodies for this Plan.

The Verification Plan sets out the requirements for gathering data to demonstrate that the remediation has met the required remediation objectives and criteria. The Verification Plan presents the requirements for a wide range of issues including the level of supervision, sampling and testing regimes for treated materials, waste and imported materials, required monitoring works during and post remediation, how compliance with all licenses and consents will be checked etc. Agreement should again be sought of the appropriate statutory bodies for the Verification Plan. On completion of the remediation a Verification Report should be produced to provide a complete record of all remediation activities on site and the data collected as required in the Verification Plan. The Verification Report should demonstrate that the remediation has met the remedial targets to show that the site is suitable for the proposed use.



APPENDIX I

NOTES ON LIMITATIONS

Notes on Limitations For Geoenvironmental and Geotechnical Consultancy Services

General

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The findings and opinions are relevant to the dates when the assessment was undertaken, but should not necessarily be relied upon to represent conditions at a substantially later date. In particular, seasonal groundwater levels, with the effects of precipitation, may affect the conditions found during the investigation. The report should be read in conjunction with the further Notes on Limitations included in Appendix A.

Where opinions expressed in this report are based on current available guidance and legislation, no liability can be accepted by CC GEOTECHNICAL LTD for the effects of any future changes to such guidelines and legislation. Additional information, improved practices, new guidance, changes in legislation, or amendments to design proposals, may necessitate this report having to be reviewed in whole or in part after that date. Opinions and interpretations are not accredited by UKAS.

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Phase I Environmental Audits / Desk Studies

The work undertaken to provide the basis of a Phase 1 Desk Study report comprises a study of available documented information from a variety of sources (including the client), together with (where appropriate) a brief walk over inspection of the site and meetings and discussions with relevant authorities and other interested parties. The opinions given in a Desk Study report have been dictated by finite data on which they are based and are relevant only to the purpose for which the report was commissioned. The information reviewed should not be considered exhaustive and has been accepted in good faith as providing true and representative data pertaining to site conditions. Should additional information become available which may affect the opinions expressed in the report, CC GEOTECHNICAL LTD reserves the right to review such information and to modify the opinions accordingly.

It should be noted that any risks identified in this report are perceived risks based on the information reviewed; actual risks can only be assessed following a physical investigation of the site.

Phase II Environmental Audits

The investigation of the site has been carried out with the intention of providing sufficient information concerning the type and degree of contamination, and ground and groundwater conditions to allow a reasonable risk assessment to be made. The objectives of the investigation have been limited to establishing the risks associated to potential human targets, building materials, the environment (including adjacent land), and surface and groundwater.

The amount of exploratory work and chemical testing undertaken may have been restricted by the timescale available, and the locations of the exploratory holes may have been restricted to areas unoccupied by the building(s) on the site, and further restricted by the existence of buried services. A more comprehensive investigation may be required if the site is to be redeveloped as, in addition to risk assessment, a number of important engineering and environmental issues may need to be resolved.

For those reasons, if costs have been included in relation to site remediation these must be considered as tentative only and must, in any event, be confirmed by a qualified quantity surveyor.

The exploratory holes undertaken, investigate only a small volume of the ground in relation to the size of the site, and can only provide a general indication of site conditions. The number of sampling points and the methods of sampling and testing do not preclude the existence of localised "hotspots" of contamination where concentrations may be significantly higher than those actually encountered.

Geoenvironmental Ground Investigations

The investigation of the site has been carried out to provide sufficient information within the agreed scope of the investigation, under the general headings of type and degree of contamination, geotechnical characteristics, and ground and groundwater conditions, to provide a reasonable assessment of the environmental risks together with engineering and development implications.

If costs have been included in relation to the site remediation, these must be confirmed by a qualified quantity surveyor.

The exploratory holes undertaken, investigate only a small volume of the ground in relation to the size of the site, and can only provide a general indication of the site conditions. The opinions provided and recommendations given in this report are based on the ground conditions apparent at the site of each of the exploratory holes. There may be ground conditions present on the site which have not been disclosed by this investigation, and which have therefore not been taken into account in this report.

The comments made on groundwater conditions are based on observations made at the time that site work was carried out. It should be noted that groundwater levels will vary owing to seasonal, tidal, weather, or other effects.

The risk assessment and opinions provided, inter alia, take into consideration currently available guidance relating to acceptable contamination concentrations; no liability can be accepted for the retrospective effects of any future changes or amendments to these values.