



# **Ground Investigation (Interpretative) Report**

Project D1 Employment Land, Graven Hill, Bicester

November 2020

**Waterman Infrastructure & Environment Limited**

5th Floor, One Cornwall Street, Birmingham, B3 2DX  
[www.watermangroup.com](http://www.watermangroup.com)

**Client Name:** Graven Hill Village Development Company Limited  
**Document Reference:** WIE11386-159-1.1.2-GIR  
**Project Number:** WIE11386-159

### Quality Assurance – Approval Status

This document has been prepared and checked in accordance with Waterman Group's IMS (BS EN ISO 9001: 2015, BS EN ISO 14001: 2015 and BS OHSAS 18001:2007)

Issue	Date	Prepared by	Checked by	Approved by
1	November 2020	Tom Bonsall Graduate Engineer	Phil Edge Associate	Phil Edge Associate

Comments

## Disclaimer

This report has been prepared by Waterman Infrastructure & Environment Limited, with all reasonable skill, care and diligence within the terms of the Contract with the client, incorporation of our General Terms and Condition of Business and taking account of the resources devoted to us by agreement with the client.

We disclaim any responsibility to the client and others in respect of any matters outside the scope of the above.

This report is confidential to the client and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies on the report at its own risk.

## Contents

<b>1. INTRODUCTION .....</b>	<b>1</b>
1.1 Objectives .....	1
1.2 Regulatory Context .....	1
1.3 Limitations .....	2
<b>2. BACKGROUND INFORMATION .....</b>	<b>4</b>
2.1 Site Location .....	4
2.2 Site Description .....	5
2.3 Site History .....	5
2.4 Previous Ground Investigation Data .....	6
2.5 Recorded Geology .....	6
2.6 Environmental Setting .....	6
2.6.1 Hydrogeology .....	6
2.6.2 Hydrology .....	7
2.7 Existing Services .....	7
<b>3. PRELIMINARY CONCEPTUAL SITE MODEL .....</b>	<b>8</b>
<b>4. GROUND INVESTIGATION METHODOLOGY .....</b>	<b>10</b>
4.1 Design Rationale and Investigation Locations .....	10
4.2 Quality Control .....	10
4.3 Health and Safety .....	10
<b>5. FIELDWORK .....</b>	<b>11</b>
5.1 Constraints .....	11
5.2 Ground Investigation .....	11
5.3 Soil Sampling .....	12
5.4 Monitoring Wells .....	12
5.5 Groundwater Monitoring .....	12
5.6 Ground Gas Monitoring .....	12
5.7 Chemical Contamination Laboratory Analysis .....	12
5.8 Geotechnical Laboratory Analysis .....	13
<b>6. RESULTS .....</b>	<b>14</b>
6.1 Geological Strata .....	14
6.2 Underground Structures and Obstructions .....	15
6.3 Visual and Olfactory Evidence of Potential Contamination .....	15
6.4 Groundwater Levels .....	15
6.5 Ground Gas .....	16
<b>7. GEOENVIRONMENTAL TESTING .....</b>	<b>17</b>
<b>8. GEOTECHNICAL TESTING .....</b>	<b>19</b>

8.1	In-Situ Testing .....	19
8.1.1	Standard Penetration Tests .....	19
8.1.2	Dynamic Cone Penetrometer (DCP) Testing.....	19
8.2	Laboratory Testing .....	20
8.2.1	Atterberg Limit Determinations and Natural Moisture Content .....	20
8.2.2	Particle Size Distribution (PSD) Testing .....	22
8.2.3	Compaction Testing .....	22
8.2.4	Unconsolidated Undrained Triaxial Testing .....	23
8.2.5	Consolidation Test Results .....	24
8.2.6	pH Value and Water Soluble Sulphate (SD1 Suite).....	24
8.3	Excavations, Trench Shoring & Dewatering .....	25
<b>9.</b>	<b>GENERIC ASSESSMENT CRITERIA .....</b>	<b>26</b>
9.1	Site Specific Information used to Support the Generic Risk Assessment .....	26
<b>10.</b>	<b>ENVIRONMENTAL ASSESSMENT .....</b>	<b>28</b>
10.1	Risk to Human Health – Soil .....	28
10.2	Ground Gas Assessment .....	28
10.3	Risk to Controlled Waters .....	29
10.4	Risk to Construction Workers .....	29
10.5	Final Conceptual Model .....	30
<b>11.</b>	<b>GEOTECHNICAL ASSESSMENT .....</b>	<b>31</b>
11.1	Proposed Development .....	31
11.2	Characteristic Values .....	31
<b>Tables</b>		
Table 1:	Site History .....	5
Table 2:	Contaminants of Concern .....	8
Table 3:	Preliminary Conceptual Model for the Site .....	8
Table 4:	Geological Strata Encountered .....	14
Table 5:	Recorded Organic Odours .....	15
Table 6:	Summary of Visual / Olfactory Evidence of Contamination .....	15
Table 7:	Groundwater/Perched Water Strikes .....	15
Table 8:	Elevated Geoenvironmental Testing Results Summary .....	17
Table 9:	Standard Penetration Test Results .....	19
Table 10:	DCP Test Results.....	20
Table 11:	Volume Change Potential .....	20
Table 12:	Particle Size Distribution Test Results .....	22
Table 13:	Compaction Testing Results .....	23
Table 14:	Unconsolidated Undrained Triaxial Testing Results .....	23

Table 15:	Summary of 1D Consolidation Testing .....	24
Table 16:	Summary of pH and Sulphate Results.....	24
Table 17:	Generic Assessment Criteria .....	26
Table 18:	Final Conceptual Model .....	30
Table 19:	Suggested Characteristic Values .....	31

## **Appendices**

- A. Topographical and Utilities Survey
- B. Exploratory Hole Records
- C. In-Situ Test Results
- D. Ground Gas and Groundwater Monitoring Results
- E. Chemical Contamination Test Results
- F. Geotechnical Test Results
- G. Generic Assessment Criteria

## 1. INTRODUCTION

### 1.1 Objectives

This report has been commissioned by **Graven Hill Village Development Company Limited (GHVDCL)** and has been prepared by **Waterman Infrastructure & Environment Ltd** (Waterman).

The subject of the report is:

**Scheme name:** Project D1 Employment Land

**Scheme details:** Employment facilities and infrastructure in the Southeast of the Graven Hill Site.

This report should be read in conjunction with the following documents:

- **Desk Study 2010:** Sites D&E, DSDC Bicester, Land Quality Assessment Phase 1 (Entec, May 2010).
- **GI 2010:** Sites D&E, DSDC Bicester, Land Quality Assessment Phase 2 (Entec, September 2010).
- **2015 3D Topographical and Utilities Survey** of LTA2 by MK Surveys.

The objectives of the investigation were as follows:

- To provide an exploratory investigation as defined by BS5930 and BS10175 to address potential geotechnical and geoenvironmental constraints;
- Undertake geotechnical testing on shallow soils underlying the Site to obtain geotechnical design parameters; and
- Undertake geoenvironmental testing on shallow soils to inform the Conceptual Site Model and provide information to inform a Remediation Strategy for the proposed development.

This assessment has been undertaken in general accordance with the procedures within the Environment Agencies 'Land Contamination Risk Management (LCRM)' document, 2020 and forms a decision record in relation to the assessment of the site. The report also provides a refined conceptual model based on the findings of the ground investigation, an evaluation of potential risks and recommendations relating to any necessary remediation.

At the time of reporting, a proposed layout was not available, however it is anticipated that a number of the existing warehouse units will be retained and additional industrial buildings constructed.

### 1.2 Regulatory Context

The National Planning Policy Framework (NPPF) 2019, sets out Government planning policy for England and how this is expected to be applied to development. Paragraph 170 (e) and (f) of Section 15 – Conserving and enhancing the natural environment of the NPPF relate to contaminated land matters and state that:

Planning policies and decisions should contribute to and enhance the natural and local environment by:

- (e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans; and

- (f) remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate.

Planning policies and decisions should ensure that:

- the site is suitable for its new use taking account of ground conditions and land instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including land remediation or impacts on the natural environment arising from that remediation;
- after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and
- adequate site investigation information, prepared by a competent person, is presented.

In doing so, local planning authorities should focus on whether the development itself is an acceptable use of the land and the impact of the use, rather than the control of processes or emissions themselves where these are subject to approval under pollution control regimes. Local planning authorities should assume that these regimes will operate effectively. Equally, where a planning decision has been made on a particular development, the planning issues should not be revisited through the permitting regimes operated by pollution control authorities."

In order to assess the contamination status of the Site, with respect to the proposed end use, it is necessary to assess whether the Site could potentially be classified as "Contaminated Land", as defined in Part IIA of the Environmental Protection Act 1990 and Contaminated Land Statutory Guidance 2012. This is assessed by the identification and assessment of potential pollutant linkages. The linkage between the potential sources and potential receptors identified needs to be established and evaluated.

To fall within this definition, it is necessary that, as a result of the condition of the land, substances may be present in, on or under the land such that:

- a) significant harm is being caused or there is a significant possibility of such harm being caused; or
- b) significant pollution of controlled waters is being caused, or there is significant possibility of such pollution being caused.

It should be noted that DEFRA has advised (Ref. Section 4, DEFRA Contaminated Land Statutory Guidance 2012) Local Authorities that land should not be designated as "Contaminated Land" where:

- a) the relevant substance(s) are already present in controlled waters;
- b) entry into controlled waters of the substance(s) from land has ceased; and
- c) it is not likely that that further entry will take place.

These exclusions do not necessarily preclude regulatory action under the Environmental Permitting (England and Wales) Regulations 2016, and subsequent amendments, which make it a criminal offence to cause or knowingly permit a water discharge of any poisonous, noxious or polluting matter to controlled waters. In England and Wales, a works notice may be served by the regulator requiring appropriate investigation and clean-up.

### **1.3 Limitations**

The assessment was undertaken in accordance with the scope and terms agreed between Waterman and Graven Hill Village Development Company Limited (GHVDC). The benefit of this report is made to GHVDC.

The information contained in this report is based on a review of third party historical ground information, the Geotechnics Ltd Factual Ground Investigation Report, and observations made on site whilst undertaking supervision of the intrusive works.

The ground conditions reported relate only to the point of excavation and do not necessarily guarantee a continuation of the ground conditions throughout the non-inspected area of the site. Whilst such exploratory holes would usually provide a reasonable indication as to the general ground conditions, these cannot be determined with complete certainty.

Waterman has endeavoured to assess all information provided to them during this investigation but makes no guarantees or warranties as to the accuracy or completeness of this information.

The scope of this site investigation includes an assessment of the presence of asbestos containing materials in the ground at the site, but not within buildings or below ground structures (basements, buried service ducts and the like).

The conclusions resulting from this study are not necessarily indicative of future conditions or operating practices at or adjacent to the site.

Should the proposed development change, the conclusions and recommendations of this report should be reviewed and updated accordingly.

DRAFT

## 2. BACKGROUND INFORMATION

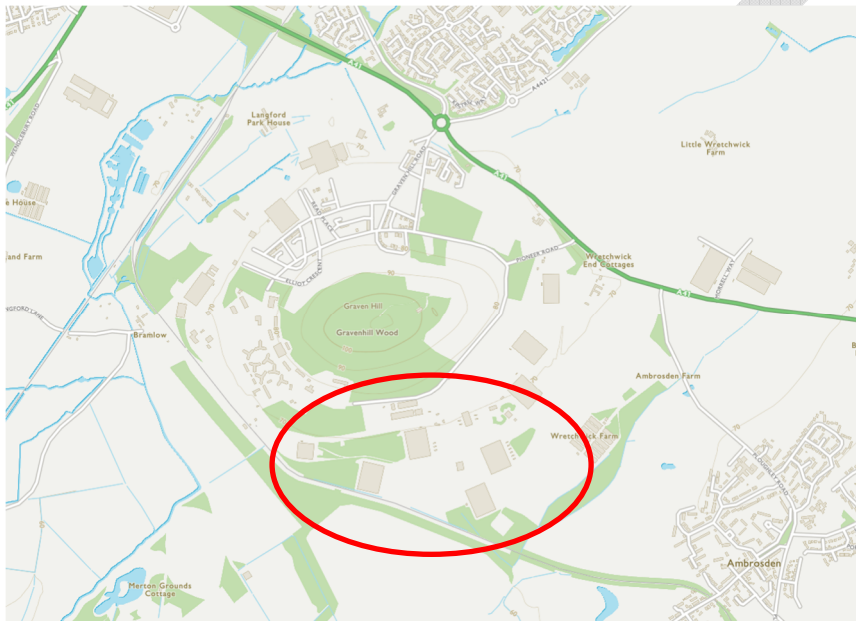
### 2.1 Site Location

The Site is located 1.5km to the south of Bicester, Oxfordshire, off the A41.

The National Grid Reference for the approximate centre of the site is SP59149 19793.

The Site is bounded to the north by Gravenhill Wood and the rest of the Graven Hill development site; to the east by grassed land, farmland and the village of Ambrosden; to the south by old railway lines and a solar power farm; and to the west by the barracks and other land still owned by the MOD.

Figure 1: Site Location



Source: Ordnance Survey (available online: <https://osmaps.ordnancesurvey.co.uk/>)

The total Site area covers approximately 28.6 hectares and is located within the administrative boundary of Cherwell District Council. The current site layout is shown in Figure 2 below.

Figure 2: Site Boundary



Source: Google (Nov 2020)

## 2.2 Site Description

The Site currently includes four large warehouse buildings, each around 10,000m<sup>2</sup>, hardstanding, disused railways lines, open grass land, tree coverage and soft landscaping, over and underground storage containers and smaller outbuildings. Many of these buildings and hardstanding areas are in various states of disrepair.

## 2.3 Site History

A review of historical maps from the Entec Land Quality Assessment Reports has been undertaken. The findings are summarised in Table 1 below:

Table 1: Site History

Published year	Site	Surroundings
1879/1880	Open agricultural fields.	Gravenhill Wood to the north/north-west.
1898/1900	No significant changes.	No significant changes.
1898/1900	No significant changes.	No significant changes.
1919/1922	No significant changes.	No significant changes.
1950	Site developed with warehouse units and a number of smaller structures,	No significant changes.

Published year	Site	Surroundings
	including what appear to be above ground air raid shelters.	
1950	No significant changes.	No significant changes.
1970	No significant changes.	No significant changes.
1983	No significant changes.	No significant changes.
1992/94	A number of small structures shown in the north of the site, including the fire station and adjacent above ground water tank.	No significant changes.
2002	No significant changes.	No significant changes.
2009	No significant changes.	No significant changes.

## 2.4 Previous Ground Investigation Data

The Entec Phase 2 investigation included two windowless sample boreholes (WSD01 and WSD02), located to target fuel tanks. No visual or olfactory evidence of hydrocarbons were recorded; ground conditions were recorded as topsoil to 0.20m, underlain by firm orange brown and brown sandy CLAY to 2.20m-2.60m depth. The sandy clay is underlain by firm to stiff grey laminated CLAY.

## 2.5 Recorded Geology

Data obtained from the BGS (available online at: <http://mapapps2.bgs.ac.uk/geoindex/home.html>) and published maps, show the recorded geology underlying the Site as:

- Artificial Ground
  - Made Ground – 2m thick
- Drift/Superficial Geology
  - No Superficial Geology is recorded in this area of the Graven Hill Site
- Solid/Bedrock Geology
  - Peterborough Mudstone Member. This is the lowest unit of the Oxford Clay Formation and consists of dark brownish grey fissile Mudstone. It is anticipated that this weathered to a sandy clay or clay near the surface
- Mining or Mineral Extraction
  - The site is not within an area at risk from old underground coal mining, and there is no surface or underground mining activity recorded at the Site.

## 2.6 Environmental Setting

### 2.6.1 Hydrogeology

The Peterborough Mudstone Member is classified as Unproductive Strata.

The Site is not in a Groundwater Source Protection Zone

### 2.6.2 Hydrology

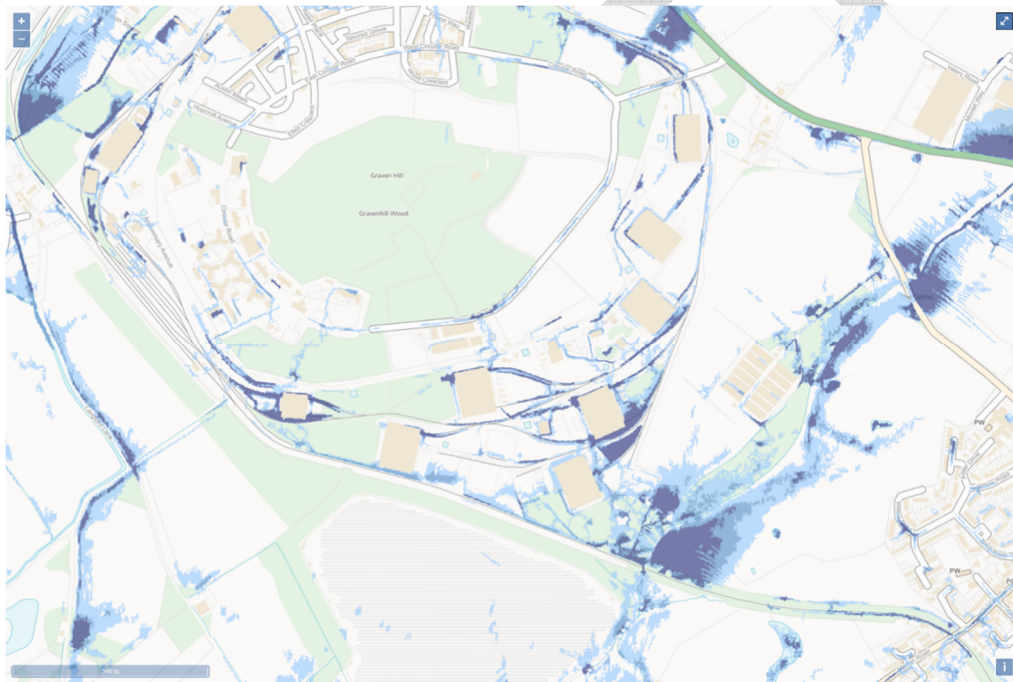
The nearest surface watercourse is an unnamed tributary of the River Ray located approximately 100m south of the Site. A series of open ditches form much of the current site drainage which appear to discharge to the surface watercourse. The confluence of the tributary and the River Ray is located approximately 1.56km to the South.

The Site is within a nitrate vulnerability zone and within a Drinking Water Safeguard Zone for Surface Water.

The Site is not within any flood zones and is not at risk from flooding from rivers or seas.

Data accessed from the Environment Agency's Flood Warning Information Service indicates the Site is generally at low risk from surface water flooding. However, some areas are recorded as high risk. An extract from the Environment Agency flood risk map is shown in Figure 3 below:

Figure 3: Environment Agency Flood Risk Mapping



Source: Environment Agency Flood Warning Information Service (available online: [://flood-warning-information.service.gov.uk/long-term-flood-risk/map](http://flood-warning-information.service.gov.uk/long-term-flood-risk/map))

### 2.7 Existing Services

At the time of the ground investigation, the site services were all still live. A utilities survey was provided prior to the works, a copy of which is presented in Appendix A.

Of particular note are:

- Surface water drainage includes numerous ditch courses and includes discharge from the adjacent barracks.
- A foul water pumping station and pumping main is present on the site, which also takes foul discharge from the barracks.

### 3. PRELIMINARY CONCEPTUAL SITE MODEL

The identified contaminants of concern and the Preliminary Conceptual Model for the Site are presented below:

**Table 2: Contaminants of Concern**

Source	Associated Contaminants
Made Ground from the former use. Includes former railway lines, former above ground heating oil and fuel tanks and localised mounded areas.	Heavy metals, hydrocarbons, asbestos.
Recent use as military warehousing including some former above ground fuel tanks (old and new) and plant rooms.	Heavy metals, hydrocarbons.
Ground gas generation due to infilled / Made Ground on the Site and from natural organic soils.	Methane and carbon dioxide.

**Table 3: Preliminary Conceptual Model for the Site**

Potential Sources	Pathways	Receptor	Risk	Justification / Mitigation
<b>Human Health</b>				
Contamination in soil associated with historical use of the Site and surrounding sites	Direct Contact Inhalation, Ingestion	Future Users Construction Workers	Site <b>Low</b>	<p>The potential risk of contamination at the Site is considered to be low.</p> <p>The information gained through ground investigation should be used and incorporated into suitable Method Statements and Risk Assessments.</p> <p>The risks during the construction phase can then be managed through use of appropriate working practices and PPE.</p>
Ground gas from on site sources	Accumulation in confined spaces Inhalation Migration	Future Users Construction Maintenance Workers	Site <b>Low</b>	<p>The potential presence of ground gases on the Site is considered low.</p> <p>The potential risk to future site users and construction workers and future maintenance workers will be dependent upon whether any confined spaces are incorporated in the detailed design (i.e. basements, deep manholes, etc).</p> <p>Any risk can be managed by appropriate risk assessment and the adoption of appropriate safety equipment.</p>

Potential Sources	Pathways	Receptor	Risk	Justification / Mitigation
<b>Controlled Waters</b>				
Mobile contaminants associated with historical use of the Site	Leaching Migration through preferential pathways/existing drainage ditches	Adjacent Watercourses	<b>Medium</b>	<p>A watercourse is present immediately to the south and the site is drained by a series of open ditches which discharge to the watercourse.</p> <p>No surface or groundwater abstractions are recorded close to the site and the Peterborough Mudstone is classified as unproductive strata. Hence the site is in an area considered to be of low to medium environmental sensitivity.</p> <p>Given the previous land uses on the Site, it is recommended that the presence of contaminants within the Made Ground are assessed, and the risk posed to controlled waters receptors quantified.</p>

## **4. GROUND INVESTIGATION METHODOLOGY**

The intrusive investigation was undertaken in general accordance with Eurocode 7, the Code of Practice for Ground Investigations BS 5930:2015 + A1:2020 and the Code of Practice for the Investigation of Potentially Contaminated Sites and its Investigation BS 10175:2011 + A2:2017.

### **4.1 Design Rationale and Investigation Locations**

The sampling locations were carefully selected in order to characterise the underlying strata and to provide geotechnical and geoenvironmental data to inform the design of the proposed redevelopment. This included targeting proposed buildings (although it is believed the proposed layout has now changed), former tanks, areas of potential Made Ground (i.e. mounds), old railway lines and sediments in drainage ditches.

All exploratory locations were the subject of an ecological inspection prior to the removal of vegetation.

### **4.2 Quality Control**

A Waterman Geo-Environmental Engineer monitored the performance, the quality of work and health and safety compliance during the investigation period. Appropriate chemical and geotechnical samples were obtained for subsequent testing at a UKAS accredited laboratory.

All contractors, including laboratories, used during this project have been approved by Waterman as a part of in-house Integrated Management System (BS ISO 9001, BS ISO 14001) procedure. This requires all third parties to demonstrate competence and a high standard of work during a regular audit scheme.

### **4.3 Health and Safety**

All work carried out on site was in accordance with Geotechnics Ltd's Health & Safety Plan.

## 5. FIELDWORK

The intrusive ground investigation was carried out in one phase, with the cable percussion boreholes, road cores, trial pits and soakaways undertaken between 13<sup>th</sup> July and the 11<sup>th</sup> August 2020. The intrusive works and monitoring were carried out by Geotechnics Ltd in accordance with the Waterman Conditions of Contract, Specification, Bill of Quantities, Drawings and Supporting Information document referenced WIE11386-137-1-2-4-GI-A01, dated 30<sup>th</sup> June 2020.

### 5.1 Constraints

At the time of the ground investigation, the site services (electricity, water, etc) were all still live, and the drainage ditch courses included discharge from the adjacent barracks. In addition, a foul water pumping station and pumping main, which also takes foul discharge from the barracks, are also present.

### 5.2 Ground Investigation

The Site was investigated as part of a larger Ground Investigation programme at Graven Hill. Any description hereafter, unless explicitly specified, refers to the section of the Geotechnics Ltd Ground Investigation conducted within the Project D1 Site Boundary, and its immediate surroundings.

- Thirteen boreholes (numbered BH801-804, 807-809, 812-815 and 818-819) were progressed using cable percussion methods to depths of between 6.00 and 6.45m below ground level (bgl), to investigate the shallow ground conditions.
- Ground gas monitoring standpipes were installed within three of the cable percussion boreholes (BH812, BH813 and BH815).
- Forty machine excavated trial pits (TP801 and TP839) were undertaken to investigate the shallow soils and extended to depths of between 0.4m and 4.5m bgl.
- Seven road cores and inspection pits (CC801, RC804-809) were dug to a depth of 1.2m bgl to investigate existing road construction and underlying materials. CC801 was extended by windowless sampling techniques to 5m depth.
- Four in-situ CBR tests using TRL DCP techniques; copies of which are included in Appendix C.
- Eight soakaway tests were undertaken in accordance with BRE DG365:2016 in TP801, TP813-815, TP817-818, TP825 and TP835. Copies of the soakaway test results are presented in Appendix C.

All exploratory holes were logged and sampled by Geotechnics Ltd under the direction of the Waterman Engineer. Exploratory hole logs that provide a record of the strata encountered, provided by Geotechnics Ltd, are presented in Appendix B.

SPTs were undertaken throughout the depth of the cable percussion boreholes, where possible, to assess the relative density of any granular deposits and the consistency of cohesive strata. Where possible, undisturbed (U100) samples, as well as bulk and disturbed samples, and environmental samples were taken.

Hand shear vane tests were carried out where possible in the trial pits.

### 5.3 Soil Sampling

During drilling and excavation, representative soil samples were collected for chemical analysis and placed into plastic tubs and glass and amber jars as appropriate. Representative bulk and disturbed samples were recovered for geotechnical testing.

Twenty seven sediment samples were obtained from the existing ditches for subsequent chemical contamination testing.

### 5.4 Monitoring Wells

On completion of the cable percussion drilling, ground gas monitoring wells were installed within three boreholes. The monitoring wells were constructed of 50mm diameter HDPE pipes with lockable covers at the surface.

Construction details for each of the monitoring wells are provided upon the respective borehole logs included within Appendix B.

### 5.5 Groundwater Monitoring

Groundwater/perched water ingress identified during the siteworks are included on the individual exploratory hole logs.

Groundwater levels were monitored on six occasions between 31 July and 28 September 2020; the groundwater levels are summarised below

- BH812 Water levels of between 1.44m and 1.95m bgl (67.87 – 67.36m OD)
- BH813 Water levels of between 2.59m and 2.73m bgl (66.51 – 66.37m OD)
- BH815 Water levels of between 1.05m and 1.36m bgl (65.18 – 64.87m OD)  
(on one visit the pipe was dry)

### 5.6 Ground Gas Monitoring

Six rounds of ground gas monitoring was undertaken during atmospheric pressures of between 994mb and 1008mb.

During the monitoring visits, concentrations of methane, carbon dioxide, oxygen, carbon monoxide and hydrogen sulphide were recorded at each installed monitoring standpipe, together with borehole gas flow readings.

A full set of ground gas monitoring results is presented in Appendix D.

### 5.7 Chemical Contamination Laboratory Analysis

Laboratory soil analysis was completed on selected samples, with the suites of analysis designed based on historical land-uses and observations of visual/olfactory evidence of contamination made during the fieldwork period. The following testing was undertaken:

#### **Soils**

- 39 samples for a metals suite

- 25 samples for Speciated Petroleum Hydrocarbons (TPHCWG)
- 44 samples for speciated PAH's
- 32 samples screened for Asbestos Fibres
- 14 samples for Soil Organic Matter
- 7 samples of macadam for Coal Tars

#### **Groundwater**

- 1 sample for Speciated Petroleum Hydrocarbons (TPHCWG)

The results of the laboratory analysis are included in Appendix E.

### **5.8 Geotechnical Laboratory Analysis**

The following geotechnical laboratory testing was completed on samples recovered from the Site:

- |  |            |
|--|------------|
| • Moisture Content                       | 57 samples |
| • Atterburg Limit Determinations         | 41 samples |
| • Water soluble sulphate SO <sub>4</sub> | 12 samples |
| • pH                                     | 12 samples |
| • Organic Matter                         | 2 samples  |
| • Loss on Ignition                       | 1 sample   |
| • Compaction (4.5kg)                     | 9 samples  |
| • Oedometer                              | 10 samples |
| • Single-Stage Triaxial                  | 17 samples |
| • Particle Size Distribution             | 11 samples |
| • BRE SD1 suite                          | 30 samples |

The results of the laboratory analysis are presented in Appendix F.

## 6. RESULTS

Detailed logs of the strata encountered are provided in the Appendix B. A summary of the general geological strata and observations made during the fieldworks is presented below.

### 6.1 Geological Strata

Ground conditions encountered across the Site during the investigation are summarised in Table 4 below.

Table 4: Geological Strata Encountered

Soil Type	Depth of Top of Stratum (m bgl)	Thickness (m)	Typical Description
MADE GROUND – hardstanding construction	0	0.20 to 0.55	Tarmac or concrete over limestone gravel
MADE GROUND – ballast over ash	0	0.30 – 0.70	Coarse gravel. (BH802 and BH804) locally with geotextile below.
	0.45 – 0.70	0.30 – 0.50	Soft and firm clay with some ash and granite
MADE GROUND - Topsoil	0	0.10 to 0.40	Grass over firm dark brown slightly sandy clay with many rootlets and roots. Occasional fine to coarse brick and clinker.
MADE GROUND –	0 – 0.50	0.30 – 0.45	Black slightly sandy slightly clayey gravel of ash, clinker and brick. Locally gravelly sand.
MADE GROUND	0.15 – 0.90	0.15 to 1.20	Firm brown mottled grey slightly sandy slightly gravelly clay with occasional rootlets and gypsum crystals.
Soft organic CLAY	0.50 – 1.00	0.15 – 1.10	Soft dark grey sandy CLAY with occasional pockets of peat (TP824), and Soft CLAY with some plant remains (TP831).
Firm orange-brown CLAY	0.10 to 1.45	0.6 to 4.8	Firm and stiff orangish brown mottled grey CLAY with rare pockets of sand and occasional selenite and gypsum crystals. Locally soft and firm to stiff.
Stiff dark grey CLAY	0.60 – 3.90	Base not proven	Firm to stiff and stiff dark green grey slightly sandy CLAY.

Organic odours were recorded in the following exploratory holes:

Table 5: Recorded Organic Odours

Exploratory Hole Location	Depth (m bgl)	Strata	Comments
BH815	3.00 – 6.45	CLAY	Moderate organic odour
TP815	1.90 – 2.70	CLAY	Strong organic odour
TP817	1.90 – 2.70	CLAY	Strong organic odour
TP819	2.30 – 3.00	CLAY	Slight organic odour
TP823	2.50 – 3.00	CLAY	Slight organic odour
TP826	2.80 – 3.00	CLAY	Slight organic odour
TP828	2.50 – 3.00	CLAY	Slight organic odour
TP831	2.30 – 3.00	CLAY	Slight organic odour

## 6.2 Underground Structures and Obstructions

A metal, temporary road mat was encountered at 0.4m bgl in TP808. The pit was extended in each direction, although this was restricted by live services, but the edge was not identified.

## 6.3 Visual and Olfactory Evidence of Potential Contamination

The following visual and olfactory evidence of contamination was recorded during the investigation:

Table 6: Summary of Visual / Olfactory Evidence of Contamination

Exploratory Hole Location	Depth (m bgl)	Strata	Comments
TP827	0.15 – 0.7	MADE GROUND	Slight hydrocarbon odour
TP831	0.10 – 0.35	MADE GROUND	Moderate hydrocarbon odour

In addition to the above, ash and tarmacadam fragments were occasionally noted within the Made Ground at various locations.

## 6.4 Groundwater Levels

Groundwater/perched water ingress/strikes, recorded during the advancement of exploratory holes, are summarised below:

Table 7: Groundwater/Perched Water Strikes

Location ID	Depth Encountered (m bgl)	Comments
BH808	1.8	Seepage
BH812	3.2	Seepage. Cased at 1.5m
BH813	4.3	Seepage. Cased at 1.5m

	4.8	Fast Inflow. Rose to 3.3m bgl in 15 minutes.
BH818	3.2	Seepage. Cased at 1.5m.
BH819	1.2	Seepage
	2.8	Seepage
RC806	0.6	Seepage
TP801	2.0	Seepage
TP803	3.0	Seepage
TP810	0.6	Seepage
TP816	3.0	Seepage
TP822	0.7	Moderate Inflow
TP826	3.0	Seepage
TP830	0.5	Fast Inflow
TP833	0.6	Slow Inflow
TP839	0.45	Fast Seepage

The water strikes were generally within the natural clays, but some were recorded in Made Ground.

As detailed in Section 5.5, standing groundwater was recorded at depths of between 1.05m and 2.73m bgl. The variance in groundwater strikes and standing levels suggest that the groundwater table lies at depth, with perched water being recorded within Made Ground and near surface clays.

## 6.5 Ground Gas

As part of the site investigation, three standpipes (BH812, BH813 & BH815) were monitored to detect the presence of ground gas. The monitoring results are summarised below:

- Maximum methane concentration <0.1% by volume
- Maximum carbon dioxide concentration 9.9% by volume (BH812 on one occasion) Remaining readings all below 4.1% v/v
- Lowest oxygen concentration 6.9% by volume (BH812)
- Maximum hydrogen sulphide concentration <1 ppm
- Maximum carbon monoxide concentration 7 ppm

No gas flow above the limit of detection (<0.1 l/hr) was recorded.

## 7. GEOENVIRONMENTAL TESTING

Geoenvironmental Testing was undertaken by Derwentside Environmental Testing Services Limited, as a subcontractor to the Ground Investigation Contractor; Geotechnics Ltd; a total of 91 soil samples were tested for specific contaminant suites.

Results were assessed using the Soil Data Assessment Tool in line with the Generic Quantitative Risk Assessment Criteria. These criteria use the recognised standards; DEFRA C4SLs, CL:AIRE 2009, LQM S4ULs 2015, CLEA SGVs 2009, CLEA v1.071.

No significant concentrations of heavy metals or petroleum hydrocarbons were recorded.

Elevated levels of Polyaromatic Hydrocarbons (PAHs) were recorded in RC810, TP826, TP827, TP838, TP837 and TP822, although four of the samples were samples of the macadam surfacing. The high B(a)P and Total PAH concentrations suggest locally that coal tars may be present within the macadam.

In addition, of the 37 samples screened for asbestos fibres, only one sample (TP804 at 0.50m) recorded a positive screening. Subsequent quantification testing confirmed the presence of loose Amosite fibres (bundles observed) at a concentration of 0.001%.

Full details of the results can be found in Appendix E and a summary of the elevated concentrations are summarised below.

**Table 8: Elevated Geoenvironmental Testing Results Summary**

Location	Stratum	Individual Contaminant	Accepted Level (mg/kg)	Recorded Level (mg/kg)
RC810 (0.15m)	MADE GROUND – black gravelly sand subbase, including slag and brick.	Benzo(b)fluoranthene	44	<b>130</b>
		Benzo(a)pyrene	35	<b>100</b>
		Di-benzo(a.h.)anthracene	3.6	<b>11.0</b>
		Total PAH	-	<b>1800</b>
TP826 (0.06m)	MACADAM Road surfacing	Benzo(b)fluoranthene	44	<b>92</b>
		Benzo(a)pyrene	35	<b>90</b>
		Di-benzo(a.h.)anthracene	3.6	<b>5.8</b>
		Total PAH	-	<b>960</b>
TP827 (0.08m)	MACADAM Road surfacing	Benzo(b)fluoranthene	44	<b>110</b>
		Benzo(a)pyrene	35	<b>97</b>
		Di-benzo(a.h.)anthracene	3.6	<b>5.8</b>
		Total PAH	-	<b>2000</b>
TP838 (0.10m)	MACADAM Road surfacing	Naphthalene	190	<b>450</b>
		Benzo(a)fluoranthene	44	<b>85</b>

		Benzo(a)pyrene	35	<b>100</b>
		Di-benzo(a.h.)anthracene	3.6	<b>5.9</b>
		Total PAH	-	<b>2400</b>
		Naphthalene	190	<b>240</b>
		Benzo(a)fluoranthene	44	<b>98</b>
TP837 (0.15m)	MACADAM Road surfacing	Benzo(a)pyrene	35	<b>110</b>
		Di-benzo(a.h.)anthracene	3.6	<b>7.0</b>
		Total PAH	-	<b>2100</b>
		Benzo(a)anthracene	170	<b>180</b>
		Benzo(b)fluoranthene	44	<b>120</b>
TP822 (0.15m)	MADE GROUND – black gravelly sand subbase, including slag and brick.	Benzo(a)pyrene	35	<b>130</b>
		Di-benzo(a.h.)anthracene	3.6	<b>13.0</b>
		Total PAH	-	<b>2700</b>
		Amosite	-	<b>0.001%</b>
TP804 (0.50m)	Railway ballast			

## 8. GEOTECHNICAL TESTING

### 8.1 In-Situ Testing

#### 8.1.1 Standard Penetration Tests

Standard Penetration Tests (SPT's) were undertaken at regular intervals within the cable percussion boreholes to provide 'N' values for empirical assessment of strength and density parameters. Detailed results of the SPT tests and blow counts are included on the borehole logs and a summary is presented in Table 9 below.

Table 9: Standard Penetration Test Results

Location ID	Stratum	Testing Depths (m bgl)	SPT 'N' Values
BH801	CLAY	1.2, 3.5, 6.0	11, 10, 31
BH802	CLAY	1.2, 3.5, 6.0	8, 23, 27
BH803	CLAY	2.2, 4.5	9, 22
BH804	CLAY	1.2, 2.5, 4.5	5, 6, 26
BH807	CLAY	2.3, 4.5	15, 24
BH808	CLAY	1.2, 2.4, 3.5, 6.0	12, 6, 19, 30
BH809	CLAY	1.2, 3.5, 6.0	11, 41, 33
BH812	CLAY	2.2, 4.2	7, 10
BH813	CLAY	1.2, 3.2, 5.5	7, 13, 22
BH814	CLAY	2.2, 4.5	7, 22
BH815	CLAY	1.2, 3.4, 6.0	9, 18, 30
BH818	CLAY	2.2, 4.1	5, 14
BH819	CLAY	1.3, 3.3, 5.5	5, 20, 31

#### 8.1.2 Dynamic Cone Penetrometer (DCP) Testing

In Situ Dynamic Cone Penetrometer (DCP) testing was undertaken at 4 locations ; full results are available in Appendix C however a summary is presented below:

Table 10: DCP Test Results

Location ID	Depth (m bgl)	CBR estimates (%)
RC804	0 – 0.53	9
	0.53 – 1.20	4
	1.20 – 2.00	15
RC807	0 – 1.50	6
	1.50 – 2.00	15
RC808	0 – 0.20	11
	0.20 – 1.20	6
	1.20 – 2.00	15
RC809	0 – 0.60	10
	0.60 – 2.00	14

## 8.2 Laboratory Testing

Copies of the full laboratory certificates are presented in Appendix F, and summarised in the following sections:

### 8.2.1 Atterberg Limit Determinations and Natural Moisture Content

Samples of natural cohesive material were tested for moisture content and Atterberg Limit determinations and the results are summarised in Table 11 below.

Table 11: Volume Change Potential

Location ID	Specimen Depth (m bgl)	>425 $\mu$ m sieve (%)	WL (%)	w <sub>p</sub> (%)	I <sub>p</sub> (%)	Modified I <sub>p</sub> (%)
BH801	1.60	3	41	18	23	22
BH802	1.00	7	46	19	27	25
BH803	1.00	7	71	24	47	44
BH803	1.50	13	57	24	33	29
BH804	1.50	15	60	25	35	30
BH807	3.00	7	64	25	39	36
BH808	1.80	14	65	26	39	34
BH809	1.20 – 1.65	5	50	19	31	29
BH809	3.50 – 3.95	3	60	29	31	30

Location ID	Specimen Depth (m bgl)	>425 $\mu$ m sieve (%)	W <sub>L</sub> (%)	w <sub>p</sub> (%)	I <sub>p</sub> (%)	Modified I <sub>p</sub> (%)
BH813	0.70 – 0.80	5	59	22	37	35
BH815	3.90	12	62	27	35	31
BH818	1.00	3	53	20	33	32
RC805	0.90	4	61	26	35	34
RC807	1.00	2	73	29	44	43
RC809	0.50	0	74	24	50	50
TP802	0.30	24	56	23	33	25
TP803	1.50	4	57	21	36	35
TP811	1.60	1	64	24	40	40
TP812	1.00	5	76	23	53	50
TP813	1.00	0	63	26	37	37
TP814	1.10	8	51	20	31	29
TP815	0.90	0	72	32	40	40
TP817	0.90	1	62	24	38	38
TP818	0.90	3	63	30	33	32
TP819	1.20	3	65	20	45	44
TP820	0.85	3	54	24	30	29
TP824	0.40	3	58	28	30	29
TP824	1.30	8	64	21	43	40
TP825	0.80 – 1.10	1	62	28	34	34
TP826	0.70	2	61	26	35	34
TP826	2.00	2	57	24	33	32
TP828	0.80	3	61	21	40	39
TP828	2.70	6	72	32	40	38
TP829	0.50	5	49	21	28	27
TP833	1.40	7	33	13	20	19
TP834A	1.00	16	68	28	40	34
TP835	0.70	8	67	27	40	37
TP835	1.20	17	60	26	34	28

Location ID	Specimen Depth (m bgl)	>425 $\mu$ m sieve (%)	W <sub>L</sub> (%)	w <sub>p</sub> (%)	I <sub>p</sub> (%)	Modified I <sub>p</sub> (%)
TP838	0.60	17	60	26	34	28
TP839	1.00	17	67	23	44	37
TP839	2.10	5	62	30	32	30

### 8.2.2 Particle Size Distribution (PSD) Testing

Samples taken from the Made Ground and Clay were tested for Particle Size Distribution (PSD). The results are summarised in the table below.

Table 12: Particle Size Distribution Test Results

Location ID	Specimen Depth (m bgl)	Lithology	Silt (%)	Clay (%)	Sand (%)	Gravel (%)	Cobbles (%)	Boulders (%)
BH812	0.10 – 0.50	CLAY	45	44	9	2	0	0
RC801	0.60	MG	6	6	14	74	0	0
RC806	0.40	MG	6	9	33	52	0	0
RC809	0.10	MG	56	37	5	2	0	0
TP801	1.00 – 1.50	CLAY	56	39	5	0	0	0
TP813	0.30 – 0.70	CLAY	32	52	16	0	0	0
TP818	1.10 – 1.60	CLAY	57	42	1	0	0	0
TP824	0.40	CLAY	47	41	12	0	0	0
TP832A	1.00	MG	12	18	20	28	22	0
TP833A	1.00	MG	14	21	24	36	5	0
TP834A	1.00	MG	3	57	8	32	0	0

### 8.2.3 Compaction Testing

Samples of materials from area of the site where it was anticipated that material would need to be excavated to provide suitable development plateaus were tested for earthworks suitability. The results of the compaction testing are summarised below:

Table 13: Compaction Testing Results

Location ID	Stratum	Depth (m bgl)	Optimum Moisture Content (%)	Maximum Dry Density (Mg/m <sup>3</sup> )	Natural Moisture Content (%)
BH812	CLAY	0.10 – 0.50	10.5	1.82	20.7
TP801	CLAY	1.00 – 1.50	13.0	1.71	32.4
TP802	MG – clay	0.30	12.5	1.76	24.4
TP813	MG - clay	0.30 – 0.70	10.0	1.84	16.7
TP818	CLAY	1.10 – 1.60	14.0	1.81	28.7
TP824	MG – clay	0.40	16.0	1.77	25.2
TP825	CLAY	0.80 – 1.10	20.8	1.52	29.8
TP832A	MG – clay	1.00	8.5	1.95	27.1
TP833A	MG - clay	1.00	12.0	1.85	27.8

#### 8.2.4 Unconsolidated Undrained Triaxial Testing

Unconsolidated Undrained Triaxial testing was carried out by Geotechnics in compliance with BS EN ISO 17892-8:2018. A summary of the results is shown in Table 14 below:

Table 14: Unconsolidated Undrained Triaxial Testing Results

Location ID	Specimen Depth (m bgl)	Undrained Shear Strength (kPa)
BH801	2.30 – 2.75	66
BH801	4.50 – 4.95	112
BH802	2.30 – 2.75	59
BH803	1.20 – 1.65	72
BH803	3.40 – 3.85	88
BH803	6.00 – 6.45	137
BH804	3.50 – 3.95	78
BH807	1.20	67
BH807	3.50	99
BH808	4.50 – 4.95	120
BH809	2.30 – 2.75	68
BH809	4.50 – 4.90	92

Location ID	Specimen Depth (m bgl)	Undrained Shear Strength (kPa)
BH812	1.20 – 1.65	58
BH812	3.20 – 3.65	38
BH813	2.20 – 2.65	97
BH814	1.20 – 1.65	35
BH814	3.40 – 3.85	51
BH815	2.30 – 2.75	66
BH815	4.60 – 5.05	69
BH818	1.20 – 1.65	55
BH818	3.20 – 3.65	27
BH819	2.30 – 2.75	55
BH819	4.30 – 4.75	90

### 8.2.5 Consolidation Test Results

One dimensional consolidation tests were undertaken on 100mm diameter specimens of natural soils at a series of confining pressures. The results of the tests are summarised within Table 15 below.

Table 15: Summary of 1D Consolidation Testing

Stratum / Geological Origin	Range of mv values at overburden plus 100kPa (m <sup>2</sup> /MN)	Qualitative Description of Compressibility / Comments
Peterborough Member	0.13 – 0.25	Medium compressibility

### 8.2.6 pH Value and Water Soluble Sulphate (SD1 Suite)

The Aggressive Chemical Environment for Concrete classifications for the soil types identified at the site have been determined in accordance with BRE Special Digest 1:2005 (SD1). SD1 requires that sites are first identified as being in one of four categories based on natural ground / 'Brownfield' conditions and pyrite content.

The results of analyses are summarised in Table below:

Table 16: Summary of pH and Sulphate Results

Strata	Determinant	No. Tests	Min	Max
MADE GROUND	pH Value	10	7.2	11.9
	Sulfate (mg / l)	10	18	2200

Strata	Determinant	No. Tests	Min	Max
PETERBOROUGH MEMBER Orange brown and brown CLAY	pH Value	25	4.2	7.8
	Sulfate (mg / l)	25	92	2200
	TPS	-	0.09	10.2
PETERBOROUGH MEMBER Dark grey CLAY	pH Value	6	4.6	6.7
	Sulfate (mg / l)	6	1600	2100
	TPS	-	3.3	6.6

### 8.3 Excavations, Trench Shoring & Dewatering

The trial pits recorded material of variable density and consistency although the pit sides were recorded as being stable during excavation. Based on these observations, it is considered likely that shallow excavations will remain stable in the short-term without the need to support or create a safe batter. The design of temporary excavations should be by a suitably qualified temporary works designer.

Locally perched water was recorded and should be anticipated when forming excavations on the site. Hence the nature of any dewatering will need to be designed on the basis of the proposed development and extent of excavations.

## 9. GENERIC ASSESSMENT CRITERIA

In line with the requirements of LCRM the results from the recent investigation have been assessed via generic quantitative risk assessment (GQRA) methods, where appropriate.

The information requirements for generic quantitative risk assessment will depend on:

- The substance being assessed;
- The pathways being considered;
- The receptors being considered; and,
- The complexity of the Site.

The Preliminary Conceptual Model developed for the Site has identified several potential pollutant linkages. These potential pollutant linkages have been investigated and the results assessed against generic assessment criteria (GAC). The GAC selected for each potential pollutant linkage together with the methods of assessment are summarised in the table below.

Table 17: Generic Assessment Criteria

Source	Pathway	Receptor	Method of Assessment and GAC
Contamination in soil associated with historical use of the Site	Direct Contact Inhalation, Ingestion	Future Site Users Construction Workers	Comparison of soil laboratory data with Generic Screening Criteria for a commercial end-use scenario and qualitative assessment. DEFRA Category 4 Screening Levels (C4SLs), LQM/CIEH S4ULs (Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3060. All rights reserved), CL:AIRE (2009)Asbestos in soils to be assessed qualitatively.
Ground gas from on and of site sources	Inhalation Migration	Future Site Users Construction and Maintenance Workers	Assessment in accordance with CIRIA665 and BS8485.
Mobile contaminants in soil associated with historical use of the Site	Leaching Migration through preferential pathways	On site drainage ditches and nearby watercourse	Preliminary assessment by comparison of laboratory data with published EQS standards, or where not available, to Drinking Water Standards.

The generic assessment criteria used in this report are included in Appendix G.

### 9.1 Site Specific Information used to Support the Generic Risk Assessment

The site specific information used to support the generic risk assessment undertaken as part of this investigation are described in the sections below:

#### Risks to Construction Workers

Risks to construction workers have been assessed qualitatively based on the concentrations of contamination recorded.

## Ground Gas

Risks to construction workers have been assessed qualitatively based on the concentrations of contamination recorded, but with reference to the guidelines outlined in CIRIA C665 and BS8485.

DRAFT

## 10. ENVIRONMENTAL ASSESSMENT

### 10.1 Risk to Human Health – Soil

Laboratory data obtained during the investigation has been compared to GAC for a commercial end-use.

The only contaminants recorded above the screening values for a commercial end use were:

- Elevated individual PAH's and the presence of Coal Tars within surface macadam (TP826, TP827, TP837, TP838). These materials are not considered a risk to site users if maintained in their current condition.
- Elevated individual PAH's and the presence of Coal Tars within Made Ground materials below the macadam surfacing. These materials are not considered a risk to site users unless exposed at the surface in the future development.
- Asbestos fibres within the railway ballast at TP804. These are recorded as a trace amount and are recorded at 0.50m depth, hence is currently not considered a potential risk to site users. However, the location and depth of these materials should be assessed when the proposed development is finalised. Whilst asbestos fibres were recorded in a single sample (37 samples screened), the potential for further localised asbestos fibres cannot be ruled out.

### 10.2 Ground Gas Assessment

Six rounds of ground gas monitoring have been undertaken which did not record any methane or hydrogen sulphide, a maximum carbon monoxide concentration of 7ppm and a maximum carbon dioxide concentration of 9.9% v/v. No gas flow was recorded.

An empirical, semi-quantitative approach has been used to characterize the ground gas risk for the site. This approach derives an appropriate gas screening value (GSV), or several GSVs if the site is zoned. The GSV is then used to select an appropriate Characteristic Situation (CS) for design and selection of the choice of protective measures.

The borehole flow rate  $Q_{hg}$  (in L/h) has been calculated for each monitoring location and each monitoring event (for each hazardous gas) using the following equation:

$$Q_{hg} = q \left( \frac{C_{hg}}{100} \right)$$

Where: -

$Q_{hg}$  is the borehole hazardous gas flow rate  
 $q$  is the measured flow rate (in litres per hour) of combined gases from the monitoring standpipe  
 $C_{hg}$  is the measured hazardous gas concentration (in % volume/volume).

The GSV has been taken as the maximum  $Q_{hg}$  measured for all the monitoring events, which gives a GSV of **0.0099 l/hr** for the site. This is consistent with a Characteristic Situation 1, although as the maximum concentration of carbon dioxide is twice the screening value, consideration should be given to increasing the Characteristic Situation to **Characteristic Situation 2**.

### **10.3 Risk to Controlled Waters**

In view of the low concentrations in soils and the minimal amount of Made Ground over the clays of the Peterborough Mudstone, the risk to Controlled Waters is deemed to be minimal.

### **10.4 Risk to Construction Workers**

Laboratory testing has identified generally low levels of contamination within site soils across the site however, localised elevated levels of PAHs were recorded in association with the existing road construction materials and a single area where asbestos fibres were recorded.

Any works that will require the excavation/removal of the existing roadways, or excavation within the area of TP804 (trace asbestos), should be carried out following appropriate risk assessments and approved method statements.

Carbon dioxide concentrations of up to 9.9% have been recorded, hence appropriate PPE Personal Protective Equipment (PPE), Respiratory Protective Equipment (RPE) and welfare facilities should be provided during any future development works.

All construction workers should be subject to mandatory health and safety requirements under the Construction, (Design and Management) (CDM) regulations 2015 and Control of Substances Hazardous to Health (COSHH) Regulations 2002.

Contractors responsible for any groundworks on site should review the contents of this report in preparing their RAMS.

## 10.5 Final Conceptual Model

Following the implementation of the ground investigation, the pollutant linkages identified within the Preliminary Conceptual Model (PCM) have been re-evaluated and reclassified in relation to the additional information obtained during the intrusive works and monitoring. The results of the reassessment are summarised in the table below.

Table 18: Final Conceptual Model

Receptor	Potential Sources	Pathways	Risk	Justification / Mitigation
<b>Human Health</b>				
Construction Workers	Elevated PAH's in existing road construction. Localised asbestos fibres (TP804) within railway ballast.	Direct contact, dermal contact, ingestion and inhalation of dust and fibres.	<b>Low Localised Medium Risk</b>	During development, ground workers will come into direct contact with the Made Ground. Construction workers should wear the appropriate Personal Protective Equipment (PPE), and adhere to good practice hygiene and safety measures, the Confined Space Regulations 1997 and the Control of Asbestos Regulations 2012.
	Ground gas (carbon dioxide)	Accumulation in internal and confined spaces with potential risk of asphyxiation.	<b>Low</b>	Slightly elevated carbon dioxide concentrations have been recorded in the monitoring visits. Monitoring of ground gas concentrations during any excavation works is recommended. Construction workers should avoid entering excavations. If entry cannot be avoided, a risk assessment should be undertaken with PPE and RPE used where appropriate, and in-line with the Confined Space Entry Regulations 1997. New buildings should incorporate appropriate gas protection measures.

The recorded concentrations are not considered to represent a risk to future site users in their current locations. However, the recorded concentrations should be assessed in relation to the future development layout and proposed levels/earthworks.

## 11. GEOTECHNICAL ASSESSMENT

### 11.1 Proposed Development

As no proposed development is available, recommended Characteristic Values have been provided below. Additional comment/recommendations can be provided once design levels and loadings are available

### 11.2 Characteristic Values

Suggested Characteristic Values are summarised in Table 19 below:

Table 19: Suggested Characteristic Values

Parameter	Testing Results	Preliminary Values	Characteristic Values
Natural MC (compaction)	MG = 16.7 – 27.8% CLAY = 20.7 – 32.4%	mc = 25% mc = 28%	
Optimum MC (omc)	MG = 8.5 – 16.0% CLAY = 10.5 – 20.8%	MG = 14% CLAY = 14% i.e. significantly wet of optimum. Needs drying/ treatment.	
Class	Class 2A (Wet Cohesive)		
Plasticity	Very high plasticity 19% to 50%	Medium to high volume change potential.	
Plasticity Index (PI)	19% to 50%	PI = 44%	
Unit Weight	As per Table 1 of BS 8002 [12]	17kN / m <sup>3</sup>	
CBR %	4% to 10% Within 950mm of ogf	CBR 4%  Clays variable and susceptible to weathering	
Undrained shear strength			
Strength Cu	Approx. 1.2m 35 - 81kN / m <sup>2</sup>	Approx. 1.2m	50kN / m <sup>2</sup>
SPT and UT	Approx. 2.5m 55 - 97kN / m <sup>2</sup>	Approx. 2.5m	60kN / m <sup>2</sup>
	Approx. 3.5m 27 - 99kN / m <sup>2</sup>	Approx. 3.5m	70kN / m <sup>2</sup>
Consolidation			
Coefficient of Volume Compressibility m <sub>v</sub>	m <sub>v</sub> = 0.13 – 0.25 m <sup>2</sup> /MN	m <sub>v</sub> = 0.25 m <sup>2</sup> /MN	
Aggressive Chemical Environment for Concrete (ACEC) (BRE Special Digest 1:2005 "Concrete in aggressive ground")			
Design Sulfate Class and Class for location	DS-3, AC-3s based on sulphate results.  Limited TPS calculations give DS-5 – further location specific testing is recommended prior to detailed design		

This table summarising Preliminary Characteristic Values shall be read in conjunction with the whole text of this report.

This table shall not be read in isolation.

The geotechnical designer/s should consider whether different characteristic values should be adopted for specific design purposes.

Different “characteristic values” may be appropriate for different designs or to different design situations. Caution should be exercised by the geotechnical designer/s.

It is the responsibility of geotechnical designer/s to apply appropriate EC 7 “Partial Factors” to appropriate “characteristic values” to obtain appropriate “design values”.

DRAFT

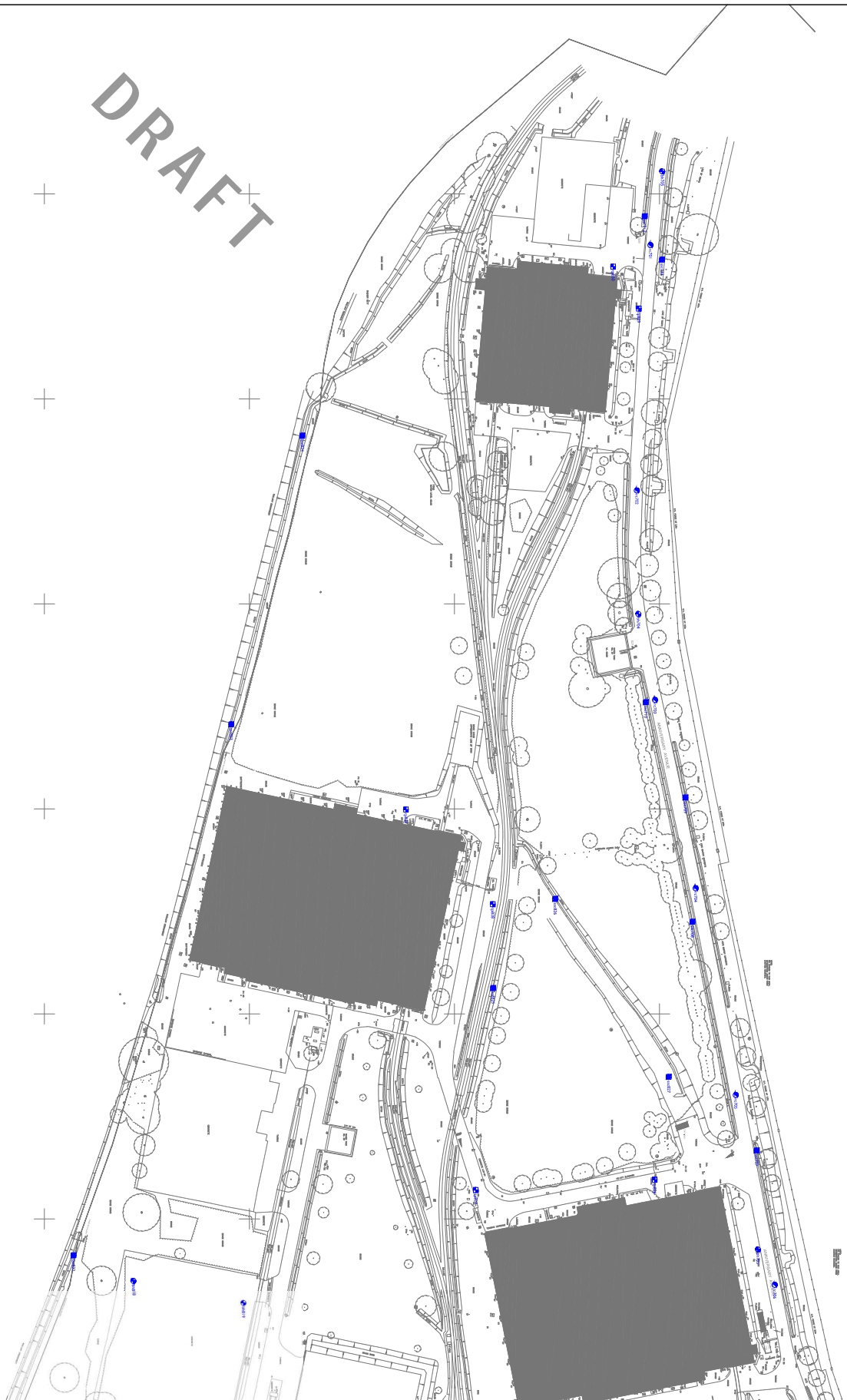


## **APPENDICES**



## **B. Exploratory Hole Records**





# GEOTECHNICS

geotechnical and geoenvironmental specialists

The Geotechnical Centre  
200 Longbridge Avenue,  
Birmingham B15 2JG  
Tel: 0121 717 4444  
Fax: 0121 717 4445  
Email: info@geotechnics.co.uk  
www.geotechnics.co.uk

Engineer:  
Waterman Infrastructure & Environment Limited

Client:  
Graver Hill Village Development Company Limited

Project:  
Graver Hill, Bicester, Land Transfer Areas 2 (LTA2)

Drawing Title:  
EXPLORATORY HOLE LOCATION PLAN

Scale: 1:1000@A1 Date: August 2020

Project No: PC207899 File Name: Geo-PC207899-001 (6)



<b>GEOTECHNICS</b> geotechnical and geoenvironmental specialists The Geotechnical Centre, 320, Longdon Avenue, Gravelly Hill, Birmingham B15 2JQ, UK www.geotechnics.co.uk	
<b>Engineer:</b> Waterman Infrastructure & Environment Limited	
<b>Client:</b> Gravelly Hill Village Development Company Limited	
<b>Project:</b> Gravelly Hill, Bicester, Land Transfer Areas 2 (LTA2)	
<b>Drawing Title:</b> EXPLORATORY HOLE LOCATION PLAN	
<b>Scale:</b> 1:1,000@A1	<b>Date:</b> August 2020
<b>Project No:</b> PC207899	<b>File Name:</b> Geo-PC207899-001(17)

©

Form REP002 Rev 4

# BOREHOLE RECORD - Cable Percussion

Draft

Project GRAVEN HILL, BICESTER, LAND TRANSFER AREA 2 (LTA2) Engineer WATERMAN INFRASTRUCTURE & ENVIRONMENT LIMITED Borehole Project No BH801 PC207899  
Client GRAVEN HILL VILLAGE DEVELOPMENT COMPANY LIMITED National Grid Coordinates 459585.2 E 220176.8 N Ground Level 69.85 m OD

Sampling			Properties			Strata	Scale 1:50		
Depth	Sample Type	Depth Cased & (to Water)	Strength kPa	w %	SPT N	Description	Depth	Legend	Level m OD
0.10	ES					PROBABLE MADE GROUND: Firm dark brown slightly sandy clay with many rootlets and roots (up to 4mm in size).	G.L.		69.85
0.10							0.20		69.65
0.20- 0.60	B		PID<0.1			PROBABLE MADE GROUND: Firm brownish grey slightly sandy slightly gravelly clay with rare rootlets. Gravel is angular to subangular fine to coarse sandstone.			
0.30	ES		PID<0.1				0.60		69.25
0.40	D					Firm orangish brown and grey slightly sandy CLAY			
0.60- 1.20	B								
0.70	D					Firm orangish brown mottled grey slightly sandy CLAY with occasional pockets (up to 2mm in size) of orangish brown sand.			
0.70	ES		PID<0.1						
1.20- 1.65	D	1.20 (DRY)			S11		1.50		68.35
1.50- 2.30	B			27					
1.60	D		PID<0.1						
1.60	ES								
2.30- 2.75	UT14	1.20 (DRY)	66	27					
2.75- 2.90	D								
3.20	D								
3.50- 3.95	D	1.20 (DRY)			S10				
4.10- 4.50	B					Stiff dark greenish grey slightly sandy CLAY with occasional shell fragments (up to 10mm in size) and a slight organic odour.	4.10		65.75
4.30	D								
4.50- 4.95	UT21	1.20 (DRY)	112	24					
4.95- 5.10	D								
5.50	D								
6.00- 6.45	D	1.20 (DRY)			S31				
						End of Borehole	6.45		63.40

Boring				Progress					Groundwater					
Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	In Mins	Depth Sealed	Remarks on Groundwater
1.20		Inspection Pit	MR/SS	G.L.			15/07/20	08:00						None encountered during boring.
6.45	0.15	Cable Percussion	MR/SS	6.45	1.20	DRY	15/07/20	18:00						

Remarks Inspection pit hand excavated to 1.20m depth and no services were found.  
ES sample = 2 x vial, 1 x plastic jar and 2 amber jar  
Water was added to assist boring between 1.20 and 6.00m.  
Radioactive screening at discrete sample depths, using a Thermo Scientific Mini 900E. No activity detected.  
Backfill details from base of hole: bentonite up to ground level.

Symbols and abbreviations are explained on the accompanying key sheet.  
All dimensions are in metres.

Logged in accordance with BS5930:2015

Logged by SI  
Figure 1 of 1  
06/11/2020

geotechnics