GIA GROUND INVESTIGATION ASSOCIATES

Phase 2 Ground Investigation Report

Park House, Mile End Road, Colwick, Nottingham

For Radford Holdings Ltd

Project No. 22121
Report Reference 22121-2
6th February 2023

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Geo-Environmental Consultants

Phase 2 Ground Investigation Report
Park House, Mile End Road, Colwick, Nottingham

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APPENDICES

1.0 INTRODUCTION

1.1 Project Understanding

Ground Investigation Associates Limited (GIA) has been instructed by Keith Simpson Associates, on the behalf of the Client Radford Holdings Ltd, to undertake Phase 2 Ground Investigation works at a site located at Park House, Mile End Road, Colwick, Nottingham. A Site Location Plan is included in Appendix 1.

The scope of our Phase 2 Ground Investigation works is presented in our quotation dated 10th October 2022 (Ref: 22121/Q), with the addition of a programme of ground gas monitoring included following production of our Phase 1 Desk Study report (see below) and detailed within our email dated 2nd December 2022.

We understand that the current buildings on site will be demolished and the site redeveloped with five new adjoined commercial units, including areas of external hardstanding and limited soft landscaping. A copy of the proposed site layout drawing is included in Appendix 2.

GIA has previously prepared the following report for the site, which should be referred to for general information on the site's geo-environmental setting, as well as the preliminary Conceptual Site Model (pCSM) established for the site:

- GIA report '*Phase 1 Geo-Environmental Desk Study, Park House, Mile End Road, Colwick, Nottingham*', for Radford Holdings Ltd, reference 22121-1, dated 8th December 2022.

It is recommended that the Desk Study is read in conjunction with this report, as the derived scope of works has been informed by the findings and recommendations of that document.

Our report has been prepared on the basis of the foregoing understanding.

1.2 Context and Objectives

Current industry good practice guidance, including the DEFRA published Land Contamination Risk Management (LCRM) model, provides guidance on how to assess and manage the risks from land contamination.

GIA has adopted a three-stage approach to land condition risk assessment, which is detailed further within the LCRM guidance referenced above. This approach is summarised in Table 1.

TABLE 1 – LAND CONDITION RISK ASSESSMENT PROCESS		
Stage 1: Risk Assessment	**Stage 2: Options Appraisal**	**Stage 3: Remediation & Verification**
1a: Preliminary Risk Assessment	**2a: Identify feasible remediation options**	3a: Develop a remediation strategy
1b: Generic Quantitative Risk Assessment	2b: Do a detailed evaluation of options	3b: Remediate
1c: Detailed Quantitative Risk Assessment	2c: Select the final remediation option	3c: Produce a verification report
		3d: Do long-term monitoring and maintenance, if required.

The following report includes a Stage 1: Generic Quantitative Risk Assessment, which aims to investigate the key environmental issues identified by the Preliminary Risk Assessment (i.e. desk study report). The findings of the current works will assist in understanding whether any further Stage 1 works are required (i.e. Detailed Quantitative Risk Assessment) and will assist in informing decisions with respect to the requirements for any necessary remedial works (i.e. Stage 2), as applicable and based on existing information.

The works have also been designed to provide initial geotechnical information for the near surface soils, to assist in an assessment of possible foundation options applicable to the proposed scheme.

1.3 Scope of Works

Our scope of works included the following:

- Commission of a subcontracted utility clearance scan of proposed exploratory hole locations.
- Advancement of a series of window sampling boreholes across accessible external areas of the site.
- Advancement of two dynamic probe holes utilising the borehole rig to investigate the deeper ground conditions.
- A programme of ground gas, vapour and groundwater level monitoring to inform a ground gas and initial vapour risk assessment at the site.
- Laboratory soils testing for key Contaminants of Potential Concern (CoPC) as identified by the desk study works, as well as for a basic suite of geotechnical soil tests, and subsequent assessments of the results.
- Revision of the initial pCSM included within the desk study report.
- Production of a standalone Phase 2 Ground Investigation report.

1.4 Limitations

This report has been prepared in accordance with the GIA Limitations detailed within Appendix 11.

It is noted that numerous buried services were identified within the site. Exploratory positions were therefore chosen to attempt to avoid buried services, whilst providing coverage across the external accessible areas of the proposed development.

2.0 GROUND INVESTIGATION

2.1 Introduction

Ground Investigation works were undertaken on 9th December 2022 and comprised the advancement of 5No. window sampling boreholes (designated WS1 to WS5) and 2No. dynamic probe holes (designated DP1 and DP2).

Exploratory positions were chosen taking account of the findings of the subcontracted utility clearance scan undertaken as part of our works, as well as to provide general coverage across the areas of the proposed buildings. The reasoning behind the positioning of the exploratory holes is detailed in Table 2.

TABLE 2 – REASONING FOR EXPLORATORY HOLE POSITIONING

Exploratory Hole	Reason For Positioning
WS1 & DP1	Positioned in the northern part of the site in areas proposed for redevelopment to inform ground conditions.
WS2	Situated close to the existing boiler house and the former off-site tanks (as indicated within the Desk Study report) and in an area proposed for redevelopment.
WS3 & DP2	Positioned close to the position of a (unused) fuel pump dispenser as identified by the Desk Study report, and in an area proposed for redevelopment.
WS4	Positioned in the eastern part of the site to inform ground conditions in an area proposed for redevelopment.
WS5	Positioned in the central-western site area to provide general ground condition information and spatial coverage.
KEY WS – Window sampling borehole DP – Dynamic probe hole	

The approximate locations of the boreholes/probe holes are shown on the Exploratory Hole Location Plan included in Appendix 3 of this report.

2.2 Ground Conditions

The Desk Study report indicated that the site may be underlain by superficial deposits comprising the Holme Pierrepont Sand and Gravel Member, in turn underlain by bedrock of the Tarporley Siltstone Formation.

The ground conditions encountered during our works are summarised in Table 3, with copies of the exploratory hole logs included in Appendix 4. Photographs showing core arisings from the boreholes are included as Plates in Appendix 5.

TABLE 3 – GROUND CONDITION SUMMARY			
Stratum	**Depth to Base (m bgl)**	**Holes Encountered**	**Typical Description**
Made Ground or Topsoil	0.50 – 1.40	All	Topsoil, macadam or concrete over gravel (sub-base), underlain by soft to firm slightly organic sandy clay and reworked/disturbed natural soils comprising soft or firm to stiff slightly sandy to sandy slightly gravelly clay, loose or loose to medium dense clayey/silty slightly gravelly sand or sandy gravel
Possible buried topsoil	0.60 – 0.70	WS2 & WS3	Soft organic slightly gravelly sandy clay or loose clayey/silty sand. Typically underlain by disturbed or reworked natural soils (see above)
CLAY (HPS+G)	1.55 – 1.95	WS1, WS3 & WS5	Soft or soft to firm slightly gravelly sandy to very sandy CLAY
SAND & GRAVEL (HPS+G)	5.00m+ (not fully penetrated)	All	Loose or loose to medium dense slightly clayey/silty SAND and GRAVEL, loose very sandy GRAVEL or loose to medium dense slightly clayey/silty very gravelly SAND. Gravel predominantly quartzite
HPS+G – Holme Pierrepont Sand and Gravel Member			

Ground Condition Comments

Surfacing materials of topsoil, macadam or concrete were typically underlain by Made Ground, locally incorporating a possible buried topsoil layer and reworked/disturbed natural soils, to depths ranging between 0.50m and 1.40m bgl. A plan showing the thickness of Made Ground encountered at each borehole location is included in Appendix 6.

The underlying natural soils locally comprised soft or soft to firm slightly gravelly sandy CLAY, which was underlain by loose or loose to medium dense slightly clayey/silty SAND and GRAVEL, with the sand and gravel varying in proportion locally.

No significant visual or olfactory evidence of any soil impaction/contamination was evident during the site works, with the boreholes all terminated within the granular Holme Pierrepont Sand and Gravel Member.

2.3 Groundwater Strikes

Groundwater was generally encountered at depths of 1.60m to 2.00m during the advancement of the boreholes, with the soils recovered wet below these depths. The indicative water strike depths, as recorded during the drilling works, are shown on the plan included in Appendix 6.

No significant visual or olfactory evidence of any water impaction/contamination was evident during the site works.

2.4 Ground Stability

The window sampling boreholes were all typically cased to a depth of 4.00m bgl in order to facilitate further advancement of the borehole. Below this depth, and upon removal of casing, the boreholes were found to be unstable and collapsing.

2.5 Standard Penetration Testing

During advancement of the boreholes, Standard Penetration Testing (SPTs) was carried out at generally 1m intervals to provide an initial indication of the near surface soil strength. The SPT results are provided on the calculation sheet and graphical chart included in Appendix 9, as well as the individual borehole logs included in Appendix 4.

At a depth of 1.00m bgl, uncorrected SPT 'N' values ranging between 2 and 11 were revealed, which typically indicate the presence of soft to firm Clay or very loose to medium dense granular strata. At 2.00m bgl, the uncorrected SPT 'N' values were typically found to range between 8 and 10, locally with a value of up to 20 recorded at WS1, which indicate typically loose to medium dense conditions within the natural soils.

Below 2.00m, groundwater was generally encountered, with uncorrected SPT 'N' values at 3.00m to 5.00m typically ranging between 5 and 9 (loose conditions) and locally with values of 16 to 20 (medium dense conditions).

The SPT results generally confirm the Engineers strength descriptions of the soils during the course of the ground investigation works.

2.6 Dynamic Probe Findings

As part of our works, two dynamic probe holes were advanced at the site, to investigate the deeper ground conditions (i.e. below those proven by the window sampling boreholes) and to attempt to ascertain the depth to possible bedrock strata; indicated to comprise the Tarporley Siltstone Formation within the desk study report.

A chart showing the blow count values within the dynamic probe holes for each 100mm increment is included in Appendix 4. The general findings are similar to the SPT results within the boreholes within the near surface horizons, with a typical blow count value of 2/100mm applicable to the soils between 1-2m depth and values of 3-4/100mm seemingly typical within the assumed superficial deposits.

The blow count values markedly increase at circa 6m within DP1 and 5.4m within DP2, which may possibly correspond to more competent superficial deposits or bedrock strata. The probe holes were terminated upon achieving refusal (i.e. a value of 50, for less than 100mm penetration) at depths of 6.8m in DP1 and 5.9m in DP2.

Within our desk study report, a review of publicly available reports for nearby developments was provided, and it is noted that similar bedrock depths were suggested by works undertaken to the east of the site, where a bedrock depth of 5.3m was recorded.

Additional ground investigation works carried out further to the east suggested bedrock depths of 4.9m to 5.4m, and proven up to 12m. It is also noted that generally shallow ground levels (circa 1.5-2.0m) were revealed by these different phases of work, which are similar to our findings.

2.7 Photo-Ionisation Detector Screening

The Desk Study report identified the presence of former Above-ground Storage Tanks (ASTs) of unknown content adjacent to the northeast of the site, as well as a fuel pump dispenser present within the southeastern extent of the site. The Preliminary Risk Assessment (desk study) therefore listed petroleum hydrocarbons as a Contaminant of Potential Concern (CoPC) given the Source-Pathway-Linkages established by the preliminary Conceptual Site Model.

To assist in assessing the presence of significant impaction of the in-situ soils and to provide an initial assessment of any potential vapour risks at the site, selected soil samples were analysed for Total Volatile Organic Compounds (TVOCs) via the use of a hand-held PhoCheck Tiger LT Photo-Ionisation Detector (PID).

A total of 16No. soil samples obtained from the boreholes, comprising samples of Made Ground and underlying River Terrace Deposits from across the site, were subjected to screening using the PID. The findings of the hand-held screening of soil samples are provided in Table 4.

TABLE 4 – SUMMARY OF HAND-HELD PHOTO IONISATION DETECTOR SCREENING

Location & Depth (m bgl)		Stratum	PID Readings (ppm Isobutylene Equivalent Units)		Comments
			Peak	Steady	
WS1	0.30	Topsoil	0.0	0.0	No discernible visual or olfactory contamination within any of the soil samples obtained from the site
	0.80	Clay	0.0	0.0	
	3.50	Sand/Gravel	0.0	0.0	
WS2	0.50	Buried topsoil	0.9	0.7	
	1.60	Sand/Gravel	0.6	0.4	
	2.50	Sand/Gravel	0.5	0.3	
WS3	0.40	Made Ground	0.1	0.0	
	1.60	Sand	0.1	0.0	
	2.70	Gravel	0.3	0.2	
WS4	0.50	Made Ground	1.1	1.0	
	0.80	Made Ground	0.1	0.0	
	1.60	Gravel	0.1	0.0	
	2.60	Gravel	0.0	0.0	
WS5	0.60	Made Ground	0.1	0.0	
	1.80	Sand/Gravel	0.4	0.0	
	2.70	Sand/Gravel	0.1	0.0	

The majority of the soil samples subjected to screening exhibited values less than 1ppm Isobutylene Equivalent Units (IEU), which has been taken as a general background threshold for volatile compounds. A single soil sample (corresponding to the Made Ground at 0.50m depth within WS4) revealed a peak PID reading of 1.1ppm, with a subsequent steady reading of 1.0ppm recorded. It is noted that the underlying soil samples all revealed negligible TVOC readings.

No discernible visual or olfactory contamination was identified by the supervising Engineer at any of the borehole locations, with a slight organic odour noted within the possible buried topsoil layers. Based on the PID screening, no significant hydrocarbon or volatile organic compound soil contamination is suggested. The PID results have been used to assist with the laboratory scheduling of soils analyses (detailed in Section 5.0).

3.0 GROUND GAS ASSESSMENT

3.1 Introduction

The Phase 1 Desk Study report identified potential sources of ground gas associated with an off-site former landfill and mapped areas of Made Ground in close proximity to the site (considered Moderate/Low risk within the pCSM). A programme of ground gas monitoring was recommended to be included as part of the Phase 2 ground investigation works.

A total of three combined ground gas and groundwater monitoring wells were therefore installed within completed boreholes during the ground investigation works (corresponding to boreholes WS1 to WS3) in order to facilitate a programme of ground gas monitoring at the site.

3.2 Monitoring Programme

Based on the site's environmental setting and our understanding of the redevelopment proposals, a total of 4No. ground gas monitoring visits have been undertaken at the site as part of our works. The findings of the monitoring programme are summarised in Table 5, with the monitoring datasheets included in Appendix 7.

Our general ground gas risk assessment methodology is included in Appendix 10.

TABLE 5 – GROUND GAS MONITORING PROGRAMME SUMMARY

Parameter	Unit of Measurement	Minimum Reading	Maximum Reading
Methane	% v/v	0.0	0.1
Carbon Dioxide	% v/v	1.0	2.1
Oxygen	% v/v	18.6	20.8
Carbon Monoxide	ppm	0	1
Hydrogen Sulphide	ppm	0	0
TVOCs	ppm IEU	0.0	36.2
Flow	l/hr	0.0	0.1 (peak)

Key
% v/v – Percentage by volume
ppm – Parts per million
IEU – Isobutylene Equivalent Units
l/hr – litres per hour

3.3 Worst-Case Atmospheric Conditions

In order to establish whether worst-case ground gas conditions have been captured at a site, it is necessary to assess the atmospheric conditions prevailing at the time of monitoring. Industry guidance historically recommended the collection of ground gas monitoring data at periods of low and falling pressure (i.e. typically considered to be less than 1000mb).

Guidance, detailed within CL:AIRE publication Technical Bulletin (TB) TB17 (dated August 2018) and titled '*Ground Gas Monitoring and Worst-Case Conditions*', defines worst-case atmospheric conditions as a 4mb pressure drop over a three-hour period.

During the course of our monitoring programme atmospheric pressure readings on the GA5000 monitoring instrument were found to range between 1001mb and 1018mb.

In order to assess the atmospheric pressure trend over the hours preceding the monitoring visits, we have made reference to the Met Office Weather Observations Website (WOW). The closest recorded weather station to the site is identified as Lodge Farm, Gunthorpe, which is situated circa 7.5km northeast of the site. This station does not appear to record pressure at the station location, however Mean Sea Level (MSL) pressure is listed and has been referred to for comparison purposes.

The pressure readings recorded during our monitoring visits, together with the corresponding pressure readings taken from the closest Weather Station and for the three-hours prior to monitoring (times denoting the commencement of testing at each well installation are included on the monitoring datasheets included in Appendix 7) are detailed in Table 6.

TABLE 6 – ATMOSPHERIC PRESSURE READINGS SUMMARY

Date of Visit	Pressure during monitoring (GA5000)	Lodge Farm (3-hrs preceding) (MSL pressure)	General Pressure Trend
16/12/2022	1017	1016 – 1017	Rising
21/12/2022	1001	1004 – 1002	Falling
06/01/2023	1011	1011	Steady
20/01/2023	1018	1014 – 1017	Rising

All listed pressure readings in millibars (mb)
MSL – Mean Sea Level

The readings from the on-site instrumentation (GA5000) and the Lodge Farm weather station show generally consistent readings across each of the four visits. As is indicated by Table 6, a majority of the readings were obtained at periods of steady or rising atmospheric pressures, although a reading at falling pressure (and at relatively low pressure) was captured during the second visit on 21st December 2022.

Whilst worst-case conditions were not obtained in strict accordance with TB17, given the consistency of the ground gas readings, the absence of any notable flow readings and the general pressure trends recorded (including a period of falling pressure), the dataset is considered suitably representative for assessment purposes.

3.4 Groundwater Monitoring

During the course of the ground gas monitoring programme, each well installation was measured with a dipmeter in order to assess the presence of any standing groundwater levels in the wells.

The water levels recorded during the monitoring programme, in addition to the indicative standing water level recorded during the site works, are summarised in Table 7.

TABLE 7 – GROUNDWATER LEVEL MONITORING SUMMARY

Well Reference	Site Works	Visit 1	Visit 2	Visit 3	Visit 4
WS1	2.00	2.02	1.91	1.77	1.84
WS2	1.70	1.68	1.56	1.42	1.48
WS3	1.85	1.89	1.77	1.62	1.69
All readings are in metres below ground level (m bgl)					

Generally consistent ranges in standing groundwater levels were recorded throughout the monitoring programme across each of the three wells, with levels broadly similar to those recorded during the course of the site works. Groundwater levels were found to rise slightly (circa 0.20m from initial site works levels) towards the end of the monitoring programme, which may be a result of general or seasonal weather conditions.

However, on all occasions, the water levels recorded were such that the wells were viable for ground gas monitoring purposes.

3.5 Soil Gas Assessment

The methodology that GIA has adopted for the provision of a ground gas risk assessment is detailed in Appendix 10. Our assessment of the monitoring data acquired during the ground gas monitoring programme is detailed in the following sections.

Carbon Monoxide

Carbon Monoxide (CO) concentrations were recorded at peak concentrations of up to 1ppm, with steady readings typically recorded as 0ppm. As noted in Appendix 10, the HSE Long-Term Exposure Limit for CO over an eight-hour period is 30ppm, with a short-term exposure limit of 200ppm over a fifteen-minute period.

The concentrations of CO recorded at the site are therefore below the eight-hour limit, and CO is considered not to represent a key ground gas risk driver at the site.

Hydrogen Sulphide

Hydrogen sulphide (H_2S) concentrations were recorded below detection level (i.e. <1ppm) during the monitoring programme. H_2S is therefore considered not to represent a key ground gas risk driver for the site.

Recorded Flow Readings

A maximum peak flow reading of 0.1 l/hr was recorded during the monitoring programme, with steady readings across all visits and each of the wells found to be 0.0 l/hr.

Borehole Hazardous Gas Assessment (Qhg)

In general accordance with BS8485:2015+A1:2019 and as detailed in Appendix 10 (Risk Assessment Methodology for Ground Gases; Section C1.2), we have calculated a borehole hazardous gas flow rate (Qhg) for each monitoring visit and for each of the wells. The Qhg is derived utilising the following equation:

Equation 1: $Qhg = q(Chg/100)$

Where:	Qhg	=	Borehole Hazardous Gas Flow Rate
	q	=	Measured borehole flow rate (in l/hr)
	Chg	=	Measured gas concentration (in % v/v)

Qhg values have been derived for both methane and carbon dioxide, adopting the limit of detection of the GA5000 gas analyser (i.e. 0.1 l/hr) where no flow readings were recorded. The calculated Qhg values are included on the calculation sheet in Appendix 9, together with the derived Characteristic Situations based purely on the Qhg assessment.

All of the monitoring visits for the three well installations revealed individual Qhg values that would fall within a Characteristic Situation (CS) 1 classification in general accordance with BS8485:2015+A1:2019.

Additional Considerations

BS8485:2015+A1:2019, together with the guidance included in NHBC and RSK publication '*Guidance on evaluation of development proposals on sites where methane and carbon dioxide are present*' (2007), note that an increase in the characteristic situation should be considered where concentrations of carbon dioxide are above 5% v/v and methane concentrations are above 1% v/v.

No ground gas readings above either of the indicative thresholds were recorded during the monitoring programme, therefore no additional increase in the site ground gas classification is considered to be necessary for the recorded soil gas concentrations alone.

3.6 Vapour Assessment

As part of the ground gas monitoring programme, a portable hand-held PhoCheck Tiger LT Photo-Ionisation Detector (PID) was mobilised to site to obtain readings of Total Volatile Organic Compound (TVOC) concentrations of the well headspaces.

The PID was operated in parallel with the GA5000 instrumentation, with the PID inlet attached to the exhaust port of the ground gas analyser. Simultaneous readings of the PID and gas probe were therefore obtained, without potentially sacrificing the loss of volatile vapours or lighter ground gases by undertaking sequential monitoring.

PID readings were obtained on each occasion during the monitoring programme and revealed concentrations ranging between 0.0ppm and 36.2ppm Isobutylene Equivalent Units (IEU), with the highest concentrations revealed during the first monitoring visit on 16th December 2022. On subsequent visits the PID readings were markedly lower than the initial visit, falling to 0.0ppm or 0.1ppm IEU on the final visit.

It is noted that the initial readings are substantially higher than the PID screening of the soil samples obtained during the site works (see Section 2.7), whereby no significant TVOC concentrations were recorded within the soils. There is therefore uncertainty over the source of the initially higher TVOC readings, although it is possible that they may be associated with localised contaminant migration through the shallow groundwater (noting that the first visit was undertaken during sub-zero degree Celsius conditions, which may possibly have contributed to these readings).

3.7 Ground Gas Regime Classification

Due to the identification of elevated volatile vapours during the course of the ground gas monitoring programme, and the current uncertainty over the corresponding source, it is recommended that a Characteristic Situation CS2 (BS8485:2015+A1:2019) classification is adopted for design purposes, with the selected membrane comprising a proprietary hydrocarbon resistant product.

It is noted that similar findings and recommendations were provided by others for nearby buildings to the east of the site due to the presence of locally elevated PID readings (attributed to potential hydrocarbon vapours).

4.0 GEOTECHNICAL LABORATORY TESTING AND ASSESSMENT

4.1 Introduction

To assist in the geotechnical characterisation of the near surface soils at the site, the following laboratory soils testing was carried out on visually representative soil samples:

- 1No. Plasticity Index (PI) and moisture content test.
- 2No. Particle Size Distribution (PSD) tests.
- 4No. Water soluble sulphate tests.
- 8No. pH tests.

All of the geotechnical laboratory soil test results are included in Appendix 8.

4.2 Plasticity Index Testing

A single Plasticity Index (PI) and Moisture Content test was carried out on a selected sample of the visibly cohesive Clay soils encountered near surface within the boreholes. In accordance with BRE 240 '*Low-rise buildings on shrinkable clay soils: Part 1*' (1993), the reported PI value may be modified to take account of the portion of sample passing a 425µm sieve (i.e. the adjustment takes account of the fines content of the soils).

The findings of the PI testing are detailed in Table 8.

TABLE 8 – SUMMARY OF PLASTICITY INDEX (PI) TEST RESULT

Stratum Type	Sample Reference & Depth (m bgl)	PI Value (%)	Percentage Passing 425µm Sieve	Modified PI Value (%)	Volume Change Potential
CLAY (HPS+G)	WS1, 1.30-1.80	11	100	11	Low
KEY HPS+G – Holme Pierrepont Sand and Gravel Member					

On the basis of Table 8, the cohesive soils encountered at the site may be classified as exhibiting low volume change potential characteristics.

4.3 Particle Size Distribution Testing

A total of two Particle Size Distribution (PSD) tests were carried out on visually representative samples of the Holme Pierrepont Sand and Gravel Member encountered during our works. The results of the PSD analyses are summarised in Table 9.

TABLE 9 – SUMMARY OF PARTICLE SIZE DISTRIBUTION (PSD) TEST RESULTS	
Sample Reference & Depth (m bgl)	**Description**
WS2, 1.30m - 2.00m	Slightly clayey/silty very sandy fine to coarse GRAVEL
WS3, 2.00m - 3.00m	Clayey/silty very sandy fine to coarse GRAVEL

The findings of the PSD testing broadly confirm the Engineer's description of the soils during the site works.

4.4 Concrete Classification

To assist in the classification for any concrete proposed to come into contact with the near surface soils, 3No. water soluble sulphate tests were carried out on visually representative samples of the Holme Pierrepont Sand and Gravel Member (including a sample of visually cohesive Clay), in addition to a further soil sample corresponding to possible disturbed natural soils (i.e. Made Ground). A total of 8No. pH tests of all main soil types were also carried out.

Our combined assessment of the laboratory soil test results is detailed in Table 10.

TABLE 10 – SUMMARY OF WATER SOLUBLE SULPHATE & pH TEST RESULTS						
Sample No.	**WSS Range (g/l)**	**Representative WSS Value # (g/l)**	**Sample No.**	**pH Range**	**Representative pH value ***	**Classification**
4	<0.010 – 0.043	**0.043**	8	6.4 – 7.8	**6.4**	**DS-1, ACEC AC-2z**
KEY: # In accordance with BRE Special Digest 1, where only a small number of samples have been tested for water soluble sulphate the maximum concentration should be used. Where 5-9 results are available, the mean of the highest two results should be used as a representative value. For 10+ samples, the highest 20% of results should be used. * In accordance with BRE Special Digest 1, the lowest pH value should be used for a small number of samples; otherwise the mean of the lowest 20% of results should be used.						

Based on Table 10 and the adoption of a Brownfield location with potentially mobile groundwater conditions, the soils analysed fall into a Design Sulfate Class of DS-1 and an ACEC AC-2z classification.

5.0 CONTAMINATION LABORATORY TESTING AND ASSESSMENT

5.1 Introduction

Based on the findings of the Phase 1 Desk Study report, a suite of chemical contamination tests was carried out as part of our Phase 2 Ground Investigation works. The testing scope was based on the findings of the preliminary Conceptual Site Model (pCSM) and included the following:

- 6No. Standard GIA Contamination suites (including metals, speciated Polycyclic Aromatic Hydrocarbons, pH and Total Organic Carbon).
- 3No. Total Petroleum Hydrocarbon tests (TPHCWG criteria).
- 3No. Laboratory Asbestos screening tests.

A summary of the testing undertaken for each different stratum type is detailed in Table 11 below, with the laboratory contamination soil test results included in Appendix 8. The findings of the PID soil screening exercise (see Section 2.7) were used in selecting samples for TPH testing.

TABLE 11 – TESTING SUMMARY

Testing Suite	Topsoil (No. of tests)	Made Ground (No. of tests)	Natural Strata (No. of tests)
GIA Standard Suite	1	3	2
TPHCWG suite	0	1	2
Asbestos screening	0	3	0

5.2 Human Health Assessment

For initial comparison purposes, we have adopted the LQM/CIEH published Suitable for Use Levels (S4ULs) or DEFRA published Category 4 Screening Levels (C4SLs) in consideration of lead, which have been termed Generic Assessment Criteria (GAC) herein.

The GAC reflect a commercial end-use, which is considered the most appropriate given the proposed redevelopment of the site.

The GIA risk assessment methodology is included in Appendix 10 for information and reference. Only determinands above the Limit of Detection (LOD) on at least one occasion have been included within our assessment.

5.2.1 Contamination Assessment

For initial assessment purposes a conservative Soil Organic Matter (SOM) content of 1.0% has been adopted for organic compounds in the first instance. This is based on the TOC ranging between <0.20% (natural Gravel soils) and 2.7% (Made Ground). Whilst the average TOC for all soil samples is 1.4% (equivalent to an average Soil Organic Matter content of 2.4%), the higher organic carbon content of the topsoil and Made Ground results in an artificially elevated SOM content when assessing the dataset in its entirety.

The results of the laboratory testing for the soils analysed from the site is summarised in Table 12 below.

TABLE 12 – CONTAMINATION ASSESSMENT SUMMARY COMBINED ASSESSMENT (COMMERCIAL END USE)				
Determinands	**No. of Samples**	**Concentration Range (mg/kg)**	**GAC Value (mg/kg)**	**GAC Exceeded & Location of Exceedances**
Metals				
Arsenic	6	6.7 – 15	640 $_{S4UL}$	No
Cadmium	6	0.34 – 1.3	190 $_{S4UL}$	No
Chromium III	6	9.7 –33	8600 $_{S4UL}$	No
Copper	6	10 – 36	68000 $_{S4UL}$	No
Inorganic Mercury	6	<0.05 – 0.10	1100 $_{S4UL}$	No
Lead	6	14 – 89	2300 $_{C4SL}$	No
Nickel	6	15 – 30	980 $_{S4UL}$	No
Selenium	6	0.44 – 1.9	12000 $_{S4UL}$	No
Zinc	6	38 – 200	730000 $_{S4UL}$	No
Speciated PAH				
Naphthalene	6	<0.10 – 0.35	190 $_{S4UL}$	No
Acenaphthylene	6	<0.10 – 0.18	83000 $_{S4UL}$	No
Acenaphthene	6	<0.10 – 0.34	84000 $_{S4UL}$	No
Fluorene	6	<0.10 – 0.12	63000 $_{S4UL}$	No
Phenanthrene	6	<0.10 – 0.76	22000 $_{S4UL}$	No
Anthracene	6	<0.10 – 0.14	520000 $_{S4UL}$	No
Fluoranthene	6	<0.10 – 1.3	23000 $_{S4UL}$	No
Pyrene	6	<0.10 – 1.5	54000 $_{S4UL}$	No
Benzo(a)anthracene	6	<0.10 – 0.50	170 $_{S4UL}$	No
Chrysene	6	<0.10 – 0.90	350 $_{S4UL}$	No
Benzo(b)fluoranthene	6	<0.10 – 1.2	44 $_{S4UL}$	No
Benzo(k)fluoranthene	6	<0.10 – 0.38	1200 $_{S4UL}$	No
Benzo(a)pyrene	6	<0.10 – 0.71	35 $_{S4UL}$	No
Speciated TPH				
Aromatic C16-C21	3	160 – 260	28000 $_{S4UL}$	No
Key S4UL – CIEH/LQM Suitable 4 Use Levels (2015). Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3833. All rights reserved. GAC reflect SOM based on 1.0%. C4SL – value for Lead taken from DEFRA publication SP1010 and based on a commercial end-use.				

In consideration of the findings of Table 12, all individual determinands analysed were present at concentrations either less than their respective Limit of Detection (LOD), including all BTEX compounds, or below Tier 1 GAC for a commercial end-use.

Asbestos Screening

As part of our laboratory soils testing suite, a total of 3No. Made Ground soil samples were subjected to screening by the laboratory for the presence of asbestos fibres.

No asbestos was identified by the laboratory within any of the samples subjected to screening and no visible evidence of any asbestos fragments were recorded by the logging Engineer during the site works.

5.3 Controlled Waters Assessment

Based on the findings of our investigation, no visual or olfactory evidence of any potentially significant mobile soil contamination was identified and no significant site wide contamination of the natural soils has been identified by our works. No visual evidence of any groundwater impaction (such as a sheen on the probe) was observed during the water level monitoring exercise.

The laboratory chemical contamination testing undertaken has not revealed any significantly elevated soil contaminant concentrations at the site. Whilst locally elevated PID readings (as TVOCs) were recorded during the ground gas monitoring programme, potentially attributable to the shallow groundwater (given the low readings recorded from the soils at the same location), no significant risks to Controlled Waters receptors have been identified at the site.

6.0 REVISED CONCEPTUAL SITE MODEL

6.1 Introduction

Industry good practice guidance requires an iterative assessment of possible Source-Pathway-Receptor linkages following the acquisition of new data for a site. This is typically undertaken via a revision to the Conceptual Site Model (CSM). For reference to the GIA CSM assessment methodology please see the information included in Appendix 10.

The preliminary CSM (pCSM) for this site was included within the previous GIA Desk Study report, and the reader is referred to that report for an understanding of the context and background to the pCSM assessment. The information acquired by our Phase 2 Ground Investigation works has been used to update and provide revised risk classifications to the model based on available information.

No new potential sources of significant contamination were identified by our Phase 2 Ground Investigation works. In consideration of the S-P-R linkages provided within our pCSM (included within our desk study report), radon was not identified as being a significant risk to the proposed redevelopment; therefore, we have excluded radon as a potential contaminant of concern from the revised CSM. All other S-P-R linkages detailed within our desk study have been updated to reflect the findings of the ground investigation works (as applicable and appropriate).

6.2 Phase 2 Conceptual Site Model

Our revised CSM, based on the findings of the Phase 2 Ground Investigation works undertaken, is included in Table 13 and adopts the same methodology for assessing the identified hazards at the site as that adopted within our desk study report.

It has been assumed that construction personnel involved with the development of the site (typically short term (acute) exposure) will adopt all necessary personal protective equipment and will conform to their Company health and safety requirements and site-specific Risk Assessments and Method Statements (RAMS). Site workers have therefore not been included within the following table, as the adoption of these appropriate mitigation measures will result in an overall low risk of exposure to the S-P-R linkages identified.

TABLE 13 - REVISED CONCEPTUAL SITE MODEL PHASE 2 GROUND INVESTIGATION						
Potential Contaminant Source & Associated Key Contaminants	**Potential Pathway**	**Potential Receptor**	**Probability of Linkage**	**Consequence of Linkage**	**Comments**	**Risk Determination**
General Made Ground • Metals & Metalloids • Polycyclic Aromatic Hydrocarbons (PAHs) • Hydrocarbon fuel/oils • Asbestos • Sulphate/acidic soils • Ground gases (e.g. methane and carbon dioxide)	Direct contact & Inhalation of dust	End Users (site workers and visitors) & Adjacent Premises	Unlikely	Medium	No significant soil contamination was identified by the ground investigation works undertaken. It is noted that the site is proposed to be redeveloped with commercial buildings with areas of hardstanding and limited soft landscaping proposed.	**Low**
	Direct contact	Construction Materials	Likely	Mild	Laboratory testing has indicated that BRE Special Digest 1 DS-1 and ACEC AC-2z conditions are applicable to the soils beneath the site. An appropriate concrete mixture should therefore be adopted for all buried concrete in contact with the ground.	**Moderate/Low**
	Permeation of organic compounds	Utilities (primarily plastic supply pipes)	Unlikely	Medium	No significantly elevated concentrations of organic contaminants were identified by the ground investigation works. The advice of utility suppliers should be sought with respect to any specific mitigation measures required for the protection of buried utilities.	**Low**
	Leaching of contaminants	Controlled Waters (i.e. groundwater and surface waters)	Unlikely	Medium	The site is indicated to be underlain by a Secondary A Aquifer associated with the mapped superficial deposits comprising the Holme Pierrepont Sand and Gravel Member, and lies within a Zone III SPZ. Based on the findings of the contamination assessment undertaken, the site is considered to represent an overall low risk to Controlled Waters receptors.	**Low**
	Vertical and lateral migration of	End Users & Building Envelope	Unlikely	Medium[#]	No significantly elevated concentrations of ground gases have been revealed by the monitoring carried out, with	**Low**

TABLE 13 - REVISED CONCEPTUAL SITE MODEL PHASE 2 GROUND INVESTIGATION						
Potential Contaminant Source & Associated Key Contaminants	**Potential Pathway**	**Potential Receptor**	**Probability of Linkage**	**Consequence of Linkage**	**Comments**	**Risk Determination**
	ground gases and vapours				no elevated volatile compound concentrations revealed by hand held screening of recovered soil samples. *# based on engineering judgement and in consideration of the setting of the site as established by the pCSM.*	
Natural Strata (Holme Pierrepont Sand and Gravel Member and Tarporley Siltstone Formation) • Metals & Metalloids • Sulphate/acidic soils • Ground gases (e.g. methane and carbon dioxide)	Direct Contact	End Users (site workers and visitors)	Unlikely	Medium	No significant contamination of the natural soils beneath the site have been identified by the ground investigation works carried out.	**Low**
		Construction Materials	Likely	Mild	Laboratory testing has indicated that BRE Special Digest 1 DS-1 and ACEC AC-2z conditions are applicable to the soils beneath the site. An appropriate concrete mixture should therefore be adopted for all buried concrete in contact with the ground.	**Moderate/Low**
	Vertical / lateral migration of ground gases	End Users & Building Envelope	Unlikely	Medium#	No significant organic content within the natural soils was identified by our ground investigation works, with no significantly elevated concentrations of ground gases indicated by the monitoring programme carried out. *# based on engineering judgement and in consideration of the setting of the site as established by the pCSM.*	**Low**
Off-site Land Uses, Former Landfill, Made Ground and Infilled Ground • Ground gases (e.g. methane and carbon dioxide) or vapours • Contamination of groundwater from	Lateral migration of contamination	End Users & Building Envelope	Low Likelihood	Medium	Locally elevated volatile compound concentrations were recorded within the headspace of the monitoring wells (primarily within WS1 in the northwest of the site). The source of the elevated TVOC concentrations is currently unknown, however may correspond to migration within the underlying shallow groundwater (although no visually or olfactory evidence of significant water contamination was revealed during our works).	**Moderate/Low**

TABLE 13 - REVISED CONCEPTUAL SITE MODEL PHASE 2 GROUND INVESTIGATION						
Potential Contaminant Source & Associated Key Contaminants	**Potential Pathway**	**Potential Receptor**	**Probability of Linkage**	**Consequence of Linkage**	**Comments**	**Risk Determination**
historic land uses in the vicinity of the site					It is recommended that BS8485:2015+A1:2019 Characteristic Situation CS2 conditions are adopted for the proposed buildings based on available information, with a suitable hydrocarbon resistant membrane selected.	

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

The following conclusions and recommendations are provided based on the findings of the ground investigation works carried out at the site, as well as any relevant information included within the previous Phase 1 Desk Study report (which we recommend is read in conjunction with this report).

7.2 Geotechnical Considerations

7.2.1 Ground Conditions Summary

Surfacing materials of topsoil, macadam or concrete were typically underlain by Made Ground, locally incorporating a possible buried topsoil layer and reworked/disturbed natural soils, to depths ranging between 0.50m and 1.40m bgl.

The underlying natural soils locally comprised soft or soft to firm slightly gravelly sandy CLAY, which was underlain by loose or loose to medium dense slightly clayey/silty SAND and GRAVEL, with the sand and gravel varying in proportion locally. The Clay and granular Sand/Gravel are considered representative of the Holme Pierrepont Sand and Gravel Member, which is indicated on the geological map publications to underlie the site.

Bedrock strata was not encountered within the window sampling boreholes, however the investigation information from the two dynamic probe holes undertaken as part of the ground investigation works seemingly indicates that higher strength superficial or bedrock strata may be present at depths ranging between 5.4m (south of the site) and 6m (north of the site). Depths to bedrock were recorded by others during investigations for sites located in close proximity to the east of the current subject site, at depths of circa 5m to 5.5m and proven up to 12m.

7.2.2 Groundwater

Groundwater was generally encountered at depths of 1.60m to 2.00m during the advancement of the boreholes, with the soils recovered wet below these depths.

The groundwater monitoring programme revealed similar groundwater depths to those recorded during the site works on the first visit, with increasingly shallower water levels recorded during subsequent visits (potentially reflecting prevailing weather/seasonal effects).

On the basis of the above, shallow groundwater conditions have been encountered at the site, with excavations below circa 1.5-2.0m likely to encounter groundwater as seepages or as standing water. The dewatering of excavations may therefore be required, with an appropriate technique adopted by the Contractor.

7.2.3 Ground Stability

The window sampling boreholes were all typically cased to a depth of 4.00m in order to facilitate further advancement of the borehole. Below this depth, and upon removal of casing, the boreholes were found to be unstable and collapsing.

It is noted that the stability of the ground can behave differently in larger excavations, compared to narrow diameter boreholes. Excavations at the site are therefore likely to require support for health and safety and/or constructional reasons. The assessment of excavations and provision of support will be the responsibility of the Contractor on site.

Due to the presence of granular soils and shallow groundwater, the presence of running sand may be encountered within excavations.

7.2.4 Foundation Design

The Made Ground encountered across the site is considered unsuitable as a founding stratum, therefore foundations will require deepening into the underlying natural soils of the Holme Pierrepont Sand and Gravel Member. However, these deposits were typically found to comprise loose water-bearing Sand and Gravel, with soft to firm cohesive soils also locally encountered near surface. It is also noted that deeper thicknesses of Made Ground than those recorded to date may be present following demolition and foundation removal of the existing buildings.

Based on the ground condition information detailed herein and the results of the in-situ strength testing, the granular Holme Pierrepont Sand and Gravel is considered suitable to support a ground bearing pressure of up to 100kN/m^2 for traditional strip, trench fill or pad foundations at depths of approximately 1.50m to 2.00m bgl, however detailed consideration of the groundwater level in relation to the base of the foundations will be required. Where groundwater is present within influencing depth of the foundation base, the allowable ground bearing pressure would be halved to 50kN/m^2, and given the fluctuations recorded during the monitoring programme, and further potential seasonal fluctuations, it is recommended that the lower bearing pressure is utilised for initial design purposes.

It is noted that constructional problems may also arise where utilising traditional foundation solutions such as strip, trench fill or pad foundations, due to the presence of shallow water-bearing strata and sidewall instability issues. The excavation of trial pits following demolition works may assist in confirming the suitability of the ground for traditional foundations, which could be undertaken by the chosen demolition/development contractor as part of their works.

Where entirely cohesive soils are encountered at founding depth within the plot (potentially applicable to the area immediately around the location of WS1), a nett allowable ground bearing pressure of 80N/m^2 is considered appropriate at a minimum founding depth of 0.75m below existing or proposed ground level, whichever being the deeper.

Based on the above and depending on detailed design and loading characteristics of the proposed units, it may be necessary to utilise ground improvement techniques where shallow foundations are the preferred method of construction within the granular superficial deposits. Ground improvement may comprise replacement and recompaction, or in-situ ground improvement techniques, subject to the advice of a specialist contractor.

Alternatively raft foundations (following geotechnical improvement of the Made Ground and superficial deposits, as necessary) or a piled foundation solution may be adopted. If the option of piles is being considered, the piling contractor may require cable percussive boreholes to investigate the depth and competency of the deeper superficial deposits and bedrock, however the findings of this report should be presented to the piling contractor for an initial assessment in the first instance.

It is recommended that, where necessary, the advice of specialist Contractors is sought to assess the most suitable and cost-effective method of ground improvement and foundation construction at the site.

Where shallow foundations are adopted, suitable reinforcement may be required where both cohesive and granular strata are encountered at founding depth.

7.2.5 Floor Slab

The floor slab design should take account of the recommended inclusion of ground gas protection within the proposed commercial buildings (see Section 7.3.4) and the identified ground and groundwater conditions. Depending on the Client preferred protection measures, the floor slab may comprise either a ground bearing floor slab, subject to consideration of tolerable settlements and loading characteristics, or a suspended floor slab with a clear ventilated void (i.e. beam and block).

Where a ground bearing floor slab is being proposed, geotechnical improvement of the Made Ground or replacement with geotechnically suitable granular fill may be required to ensure consistency across the building footprint, with proof rolling of the formation layer and provision of appropriate geotextile reinforcement included as necessary.

7.2.6 Potential Tree Influence

Where present, the near surface cohesive soils were found to exhibit low volume change potential characteristics based on the limited laboratory testing undertaken. Consideration of potential tree influence should be provided by the Structural Engineer during the design of foundations and floor slabs for the proposed units.

Where foundations are advanced to encounter the granular natural soils associated with the Holme Pierrepont Sand and Gravel Member, no specific deepening due to tree influence is considered to be necessary.

7.2.7 Sulphate Classification of Soils

Based on the testing undertaken and in general accordance with BRE Special Digest 1:2005, the soils analysed may be classified as Design Sulphate Class DS-1 and an ACEC classification of AC-2z.

The provision of an appropriate concrete mixture should therefore be adopted for all buried concrete in contact with the ground.

7.2.8 California Bearing Ratios (CBRs)

A CBR value of less than 2% should be anticipated for the general Made Ground soils, with values of 3-5% potentially applicable to the underlying natural Holme Pierrepont Sand and Gravel Member, subject to in-situ testing following sewers construction.

An appropriate thickness of granular sub-base should therefore be provided within proposed car parking or external hardstanding areas, which may require the inclusion of geotextile materials or geotechnical improvement of the near surface Made Ground, as necessary.

It is recommended that significant thicknesses of topsoil are removed from beneath any proposed external hardstanding areas to minimise the risks associated with settlement.

7.3 Environmental Considerations

7.3.1 Soil Contamination Issues – Human Health

On the basis of the laboratory testing undertaken as part of our works, the in-situ soils have been found to be chemically suitable for the proposed commercial end-use; including the topsoil, Made Ground and underlying natural soils.

No significant human health soil contamination risks have therefore been identified by our works.

7.3.2 Soil Contamination Issues – Controlled Waters

Given the absence of any significant soil contamination identified at the site, no specific remedial measures for the protection of controlled waters receptors is currently considered to be necessary for the on-site sources of contamination identified by the CSM.

A general watching brief should be maintained during the course of redevelopment works, with any anomalous ground conditions/contamination encountered dealt with in accordance with the protocol detailed within Section 7.4.5.

7.3.3 Imported Soils

Given the redevelopment proposals, it is considered unlikely that any topsoil/subsoil will require importation to the site as part of the proposed scheme. However, in the event that these soils are required to be imported, these should be both compositionally and chemically suitable for placement within their proposed destination and should be tested at source to ensure they are suitable prior to purchase and importation. The advice of a Geo-Environmental Consultant should be sought in this instance.

7.3.4 Ground Gas Issues

Radon

The Desk Study report (referenced in Section 1.1) identified that no radon precautions are required at the site, and no specific precautions in relation to radon are therefore considered to be necessary within the proposed commercial buildings.

Soil Gases & Vapour Risks

Whilst significantly elevated concentrations of soil gases (i.e. methane and carbon dioxide) have not been revealed at the site by the programme of ground gas monitoring, locally elevated volatile organic compound concentrations have been revealed by PID screening of well headspaces. Due to the nature of the general screening (as TVOCs) discrimination of individual compounds was not possible.

Based on the current uncertainty over the source of the volatile vapours (possibly corresponding to the underlying groundwater or an off-site source), it is recommended that a Characteristic Situation CS2 classification is adopted for the site, in general accordance with BS8485:2015+A1:2019. Appropriate hydrocarbon vapour precautions should therefore be included within the floor slab design of the proposed building. Based on our current understanding of the proposals (i.e. Type C building), it is anticipated that a point score of 2.5 points would be required based on the above guidance.

As an example, appropriate precautions may comprise the provision of a cast in-situ ground bearing floor slab (with mesh reinforcement) to achieve 0.5 points (Table 5 of BS8485) and an upgraded damp proof membrane to comprise a hydrocarbon resistant membrane (which would achieve 2 points where fully sealed across the building footprint and verified in accordance with CIRIA C735 '*Good practice on the testing and verification of protection systems for buildings against hazardous ground gases*').

Alternative methods of achieving the necessary point score may also be considered, as appropriate to the proposed foundation and floor slab solution. Once the mitigation proposals have been decided upon, the information should be presented to the Local Planning Authority (Gedling Borough Council) for approval and a verification/validation report prepared in due course by a third-party verifier.

We note that a similar recommendation was provided by others as part of previous investigation works within the wider industrial estate to the east (see Section 2.9 of the Desk Study report).

Alternatively, the Client may elect to undertake supplementary ground gas/vapour monitoring, groundwater and ground gas testing and risk assessment, to attempt to refine the CSM provided herein.

7.4 Development Considerations

7.4.1 Off-Site Disposal

Where the off-site disposal of soils is required, it is recommended that a copy of this report and the soil test certificates included in Appendix 8 be supplied to the Client preferred landfill operator in order to determine likely disposal costs.

Dependent on the requirements of the landfill operator, it may be necessary to undertake further laboratory testing, potentially including Waste Acceptance Criteria (WAC) testing on generated stockpiles, in due course.

Where site generated soils are proposed to be re-used on other development sites, it is noted that the screening criteria for the proposed receiving site may be different to those adopted herein. It is recommended that the soil test results are re-assessed for the proposed receiver site end-use in this instance.

7.4.2 Surface Water Disposal

As potentially identified by our previous Phase 1 Desk Study report, shallow groundwater conditions have been encountered within the superficial deposits, with water levels typically found to range between circa 1.5m and 2.0m bgl. Given the proven presence of Made Ground thicknesses at depths of up to 1.40m bgl, the use of soakaways for surface water disposal purposes is considered unlikely to be suitable for the proposed commercial units.

We therefore recommend that alternative methods of draining the site are investigated at this stage, which may include connection to existing combined sewers or potentially connecting into the possible culverted surface watercourse to the east of the site.

7.4.3 Construction Workers

Construction personnel that are likely to come into direct contact with the near surface soils at the site should wear appropriate Personal Protective Equipment (PPE) as appropriate and conform to their Company Risk Assessments and Method Statements (RAMS).

A copy of this report should be included in the site Health and Safety file, and site personnel advised of the report conclusions and recommendations.

7.4.4 Utilities

It is recommended that the advice of relevant utility providers should be sought for new buried services (including any new potable water supply pipes) proposed as part of the development and their advice adhered to.

7.4.5 Unexpected Ground Conditions

Should any ground conditions be encountered during the course of enabling or construction works that appear significantly different to those detailed herein, the following protocol should be adopted by the site Contractor:

- Anomalous ground/feature to remain in-situ.
- A suitably qualified Consultant (e.g. GIA) should be notified to attend site and inspect the anomalous ground/feature. Soil sampling and testing may then be carried out where suspected contamination is present in the ground.
- Where required by the findings of the soil testing, a remedial strategy may need to be designed and implemented (potentially including the treatment or removal of the contaminated material), followed by appropriate validation works for subsequent approval by the Local Planning Authority.

7.4.6 Legal Compliance Issues

It is the responsibility of the Client and Contractor to ensure that all necessary environmental permits or exemptions, waste protocols and permits, licenses and/or management plans are in place prior to commencing construction works at the site.

Reference to the CL:AIRE '*The Definition of Waste: Development Industry Code of Practice*' guidance document (version 2, March 2011) is recommended where the re-use of any excavated soils is proposed as part of the development.

7.5 Further Action

Based on the findings of the Ground Investigation works detailed herein, the following geo-environmental issues have been identified that will likely require further action by the Client.

TABLE 14 – FURTHER ACTION	
Geotechnical/Development Considerations	
Potential Issue	**Recommended Action**
Foundation design	Foundations should be designed by a Structural Engineer taking account of the findings and recommendations of this report.
Soakaway design	Soakaways are unlikely to be suitable for surface water disposal purposes. Alternative methods of surface water drainage should be investigated.
New utilities	The advice of utility providers should be sought for new utilities (including potable water supply) proposed within the new buildings.
Environmental Considerations	
Potential Issue	**Recommended Action**
Ground Gas & Vapour risk	Ground gas precautions are recommended within the proposed buildings, equivalent to a classification of BS8485:2015+A1:2019 Characteristic Situation CS2. It is recommended that a hydrocarbon resistant membrane is incorporated into the floor slab design of the proposed buildings, with Third Party verification of the membrane installation undertaken. Alternatively, the Client may elect to undertake an extended monitoring programme, testing and further contaminated land risk assessment, to attempt to refine the requirement for specific mitigation measures.
Statutory consultation	It is recommended that this report, and the previous Desk Study report where not already submitted, are provided to the Local Planning Authority (Gedling Borough Council) as part of the planning requirements for the scheme.

Dependent on the comments and input from the Clients design team and the Regulatory Authorities as part of the planning process, additional works to those specified in Table 14 may be required in due course.

APPENDIX 1

Site Location Plan
(Drawing No. 22121-2/01)

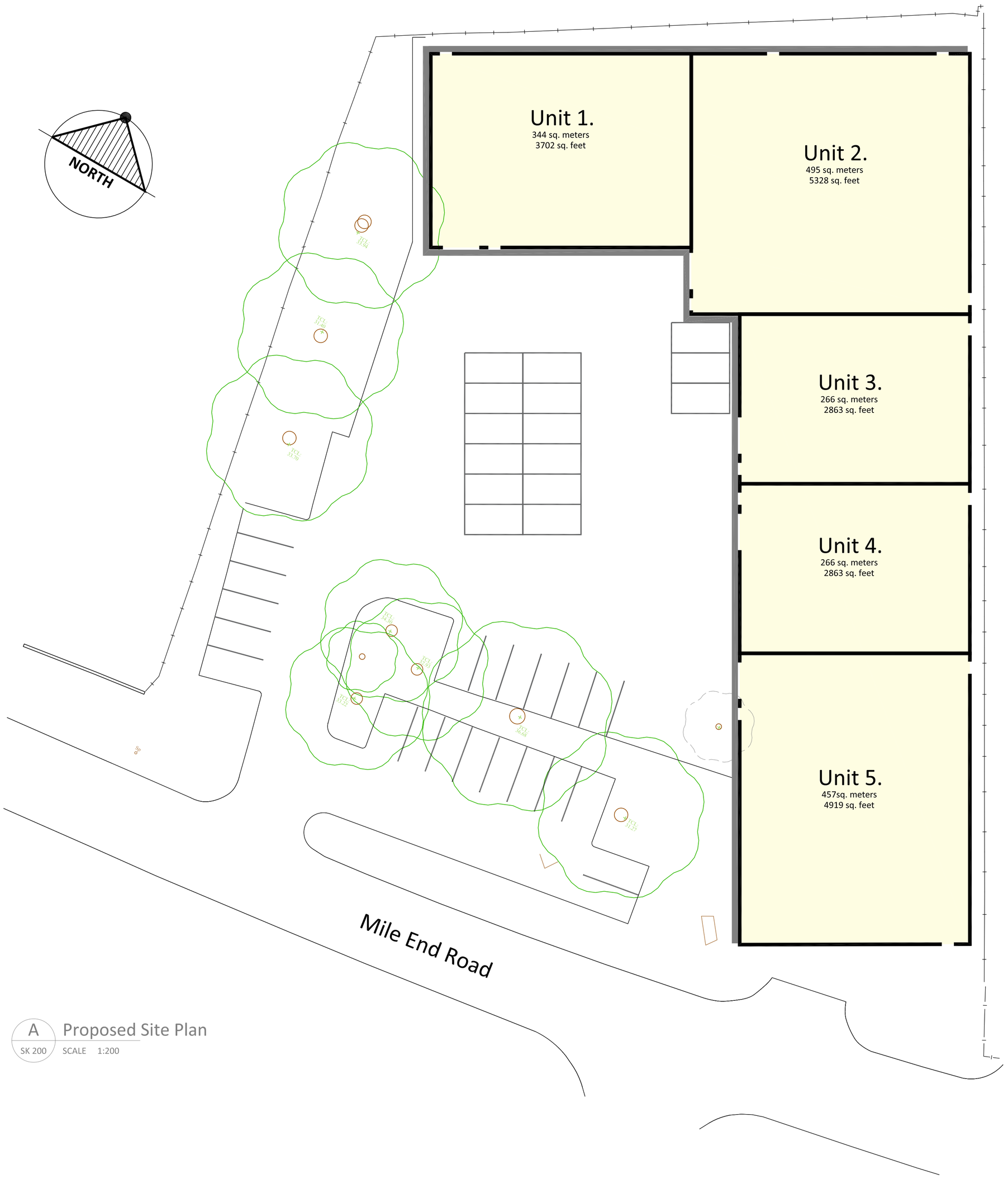
GIA GROUND INVESTIGATION ASSOCIATES

Web: www.giassociates.co.uk Email: office@giassociates.co.uk

Client Name:	Radford Holdings Ltd		
Project Name:	Park House, Mile End Road, Colwick, Nottingham		
Title:	Site Location Plan		
Project Number:	22121	Drawn By:	DH
Date Drawn:	31/01/2023	Approved By:	PA
Drawing No.		**22121-2/01**	

APPENDIX 2

Proposed Site Layout Plan



A Proposed Site Plan

SK 200 SCALE 1:200

0 10 20 30 40

SCALE BAR 1:200

rev	notes	date
1.1	Drawing revised in accordance with the clients comments.	14.07.22
1.0	First Issue	20.06.22

Meller,
The Lace Mill,
42 - 44 Derby Road,
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Tel: 01509 670036
Website: www.mellerltd.co.uk

client	Radford Holdings	created	June 2022
project	Park House Industrial Units	Drawn by: -	Checked by: -
title	Proposed Site Plan	scale	1:200

job N°	drawing N°	rev	status
220301	SK200	1.1	Preliminary

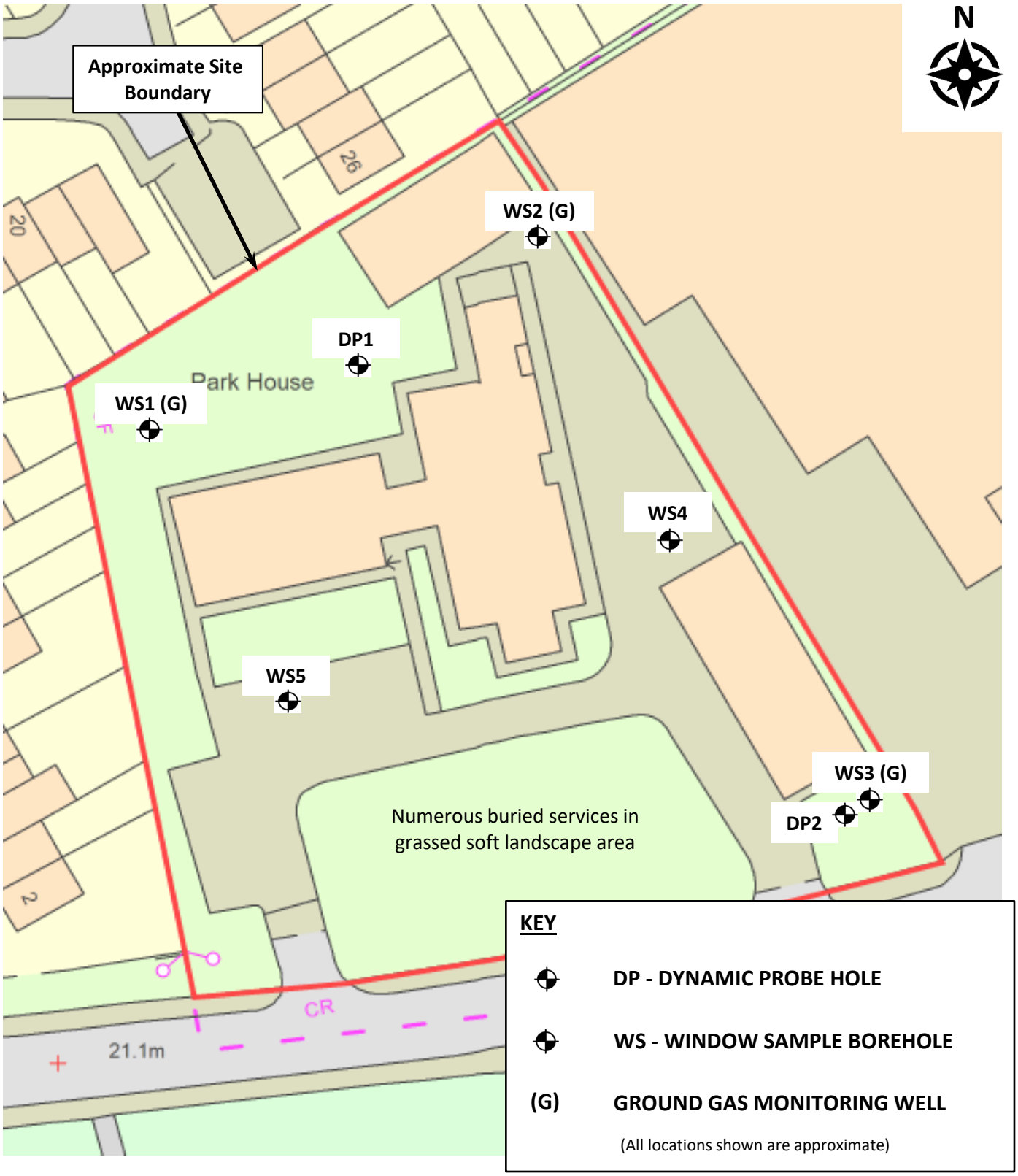
APPENDIX 3

Exploratory Hole Location Plan
(Drawing No. 22121-2/02)

GIA GROUND INVESTIGATION ASSOCIATES

Web: www.giassociates.co.uk Email: office@giassociates.co.uk

Client Name:	Radford Holdings Ltd		
Project Name:	Park House, Mile End Road, Colwick, Nottingham		
Title:	Exploratory Hole Location Plan		
Project Number:	22121	Drawn By:	PA
Date Drawn:	31/01/2023	Approved By:	DH
Drawing No.	**22121-2/02**		



KEY

- DP - DYNAMIC PROBE HOLE
- WS - WINDOW SAMPLE BOREHOLE
- (G) GROUND GAS MONITORING WELL

(All locations shown are approximate)

APPENDIX 4

Exploratory Hole Logs

GIA GROUND INVESTIGATION ASSOCIATES

WS1

Project No. 22121

Sheet 1 of 1

Samples and Tests				Description of Strata	Legend	Depth & (Thickness) (m)	Casing (m)	Ground-water	Installation
Depth (m)	Type	Sample Ref	SPT "N" Value						
				Grass over dark brown sandy slightly clayey slightly sandy rooty topsoil. Gravel includes black carbonaceous inclusions (TOPSOIL)		(0.50)			
0.30	D/J	D1				0.50			
				Soft to firm brown slightly gravelly sandy CLAY with rare fine roots. Gravel predominantly fine subrounded quartzite (HOLME PIERREPONT SAND AND GRAVEL)					
0.80	D/J	D2							
1.00 - 1.45	C		5						
1.30 - 1.80	B	B1				(1.45)			
				...becoming lighter brown in colour below 1.40m					
				...becoming brown-grey and very sandy below 1.70m					
2.00 - 2.45	C		20	Medium dense brown slightly clayey/silty SAND and GRAVEL. Sand predominantly medium to coarse grained and gravel predominantly fine to medium subrounded to rounded quartzite (HOLME PIERREPONT SAND AND GRAVEL)		1.95		▽	
2.00 - 3.00	B	B2		...becoming wet at approximately 2.00m					
3.00 - 3.45	C		19						
3.50	J	D3		...progressing into loose sandy GRAVEL with depth		(3.05)			
4.00 - 4.45	C		9	...poor sample recovery between 4.00m and 5.00m			4.00		
5.00 - 5.45	C		5	End of Borehole at 5.00m		5.00			

Remarks

1.Borehole cased to 4.00m. Sides collapsed below this depth.
2.Water encountered below approximately 2.00m.
3.Monitoring well installed: comprising plain pipe with a bentonite surround from ground level to 1.00m and slotted pipe in a gravel surround between 1.00m and 4.00m. Well sock installed across slotted section of pipe.
4.Bung, valve and lockable cover installed.

Key

D = Disturbed Sample
U = Undisturbed Sample
B = Bulk Sample
J = Jar Sample
V = Vial Sample
W = Water Sample
S = Standard Penetration Test (Split Spoon)
C = Standard Penetration Test (Cone)
▽ = Water Strike (m)
▼ = Steady Water Level (m)

Project:	Park House, Colwick			**Client:**	Radford Holdings Ltd		
Logged:	DH	**Checked:**	PA	**Field Book Ref:**	**Plant:** Competitor Rig		**Drawing Ref:**
Date:	09/12/2022	**Approved:**	PA	DH 22/01	**Scale:** 1:25		WS1

GIA GROUND INVESTIGATION ASSOCIATES

WS2

Project No. 22121

Sheet 1 of 1

Samples and Tests				Description of Strata	Legend	Depth & (Thickness) (m)	Casing (m)	Ground-water	Installation
Depth (m)	Type	Sample Ref	SPT "N" Value						
				Reinforced concrete (re-bar at 0.095m approximately 8mm in diameter)		0.10			
				(MADE GROUND)					
				Compact grey slightly clayey/silty sandy gravel (sub-base type materials)		0.35			
				(MADE GROUND)					
0.50	D/J/V	D1		Soft dark grey organic slightly gravelly sandy clay with occasional fine roots. Gravel includes fine quartzite. Recovered with an organic odour		0.60			
				(POSSIBLE BURIED TOPSOIL)					
				Firm to stiff brown slightly sandy slightly gravelly clay. Gravel includes fine to coarse subrounded to rounded quartzite and occasional red fine sandstone					
1.00 - 1.45	C		5	(POSSIBLE REWORKED NATURAL STRATA)		(0.70)			
				...recovered with dark grey mottling below approximately 0.70m and becoming gravelly below 0.90m					
1.30 - 2.00	B	B1		Loose brown slightly clayey/silty SAND and GRAVEL. Sand predominantly medium to coarse grained and gravel predominantly fine to coarse subrounded to rounded quartzite		1.30			
1.60	D/J/V	D2		(HOLME PIERREPONT SAND AND GRAVEL)					
				...recovered wet below approximately 1.70m					
2.00 - 2.45	C		8						
2.00 - 3.00	B	B2							
2.50	J	D3				(2.70)			
3.00 - 3.45	C		8	...poor recovery between 3.00m and 4.00m					
				End of Borehole at 4.00m		4.00	4.00		

Remarks

1.Borehole cased to 4.00m. Unable to take SPT at 4.00m as sampling tube stuck inside casing.
2.Water encountered below approximately 1.70m.
3.Monitoring well installed: comprising plain pipe with a bentonite surround from ground level to 1.00m and slotted pipe in a gravel surround between 1.00m and 2.00m. Well sock installed across slotted section of pipe.
4.Bung, valve and lockable cover installed.

Key

D = Disturbed Sample
U = Undisturbed Sample
B = Bulk Sample
J = Jar Sample
V = Vial Sample
W = Water Sample
S = Standard Penetration Test (Split Spoon)
C = Standard Penetration Test (Cone)
▽ = Water Strike (m)
▼ = Steady Water Level (m)

Project:	Park House, Colwick			**Client:**	Radford Holdings Ltd		
Logged:	DH	**Checked:**	PA	**Field Book Ref:**	**Plant:**	Competitor Rig	**Drawing Ref:**
Date:	09/12/2022	**Approved:**	PA	DH 22/01	**Scale:**	1:25	WS2

GIA GROUND INVESTIGATION ASSOCIATES

WS3

Project No. 22121

Sheet 1 of 1

Samples and Tests				Description of Strata	Legend	Depth & (Thickness) (m)	Casing (m)	Ground-water	Installation
Depth (m)	Type	Sample Ref	SPT "N" Value						
				Grass over dark grey-brown slightly clayey/silty very sandy rooty topsoil (MADE GROUND - TOPSOIL)		(0.30) 0.30			
0.40	D/J/V	D1		Soft brown-grey slightly gravelly very sandy clay with frequent fine roots. Gravel includes fine to medium quartzite and occasional fine brick fragments (MADE GROUND)		0.55			
				Loose dark grey-brown clayey/silty sand with occasional fine roots and fine gravel inclusions (POSSIBLE BURIED TOPSOIL)		0.70			
1.00 - 1.45	C		2	Loose brown clayey/silty slightly gravelly sand with occasional fine roots. Gravel predominantly fine quartzite (SUBSOIL)		(0.50) 1.20			
1.60	D/J/V	D2		Loose to medium dense brown slightly clayey/silty very gravelly fine to coarse grained SAND. Gravel predominantly fine to medium subrounded to rounded quartzite (HOLME PIERREPONT SAND AND GRAVEL)		(0.50) 1.70			
				Soft to firm brown slightly gravelly very sandy CLAY (HOLME PIERREPONT SAND AND GRAVEL) ...becoming wet at approximately 1.85m		1.95		▽	
2.00 - 2.45 2.00 - 3.00	C B	B	8	Loose brown wet very sandy GRAVEL of predominantly fine to medium, occasionally coarse, subrounded to rounded quartzite (HOLME PIERREPONT SAND AND GRAVEL)					
2.70	J	D3							
3.00 - 3.45	C		8			(3.05)			
4.00 - 4.45	C		5				4.00		
5.00 - 5.45	C		20	End of Borehole at 5.00m		5.00			

Remarks

1.Borehole cased to 4.00m. Sides collapsed below this depth.
2.Water encountered below approximately 1.85m.
3.Monitoring well installed: comprising plain pipe with a bentonite surround from ground level to 1.00m and slotted pipe in a gravel surround between 1.00m and 4.00m. Well sock installed across slotted section of pipe.
4.Bung, valve and lockable cover installed.

Key

D = Disturbed Sample
U = Undisturbed Sample
B = Bulk Sample
J = Jar Sample
V = Vial Sample
W = Water Sample
S = Standard Penetration Test (Split Spoon)
C = Standard Penetration Test (Cone)
▽ = Water Strike (m)
▼ = Steady Water Level (m)

Project:	Park House, Colwick			**Client:**	Radford Holdings Ltd		
Logged:	DH	**Checked:**	PA	**Field Book Ref:**	**Plant:** Competitor Rig		**Drawing Ref:**
Date:	09/12/2022	**Approved:**	PA	DH 22/01	**Scale:** 1:25		WS3

GIA GROUND INVESTIGATION ASSOCIATES

WS4

Project No. 22121

Sheet 1 of 1

Samples and Tests				Description of Strata	Legend	Depth & (Thickness) (m)	Casing (m)	Ground-water	Installation
Depth (m)	Type	Sample Ref	SPT "N" Value						
				Macadam surfacing (MADE GROUND)		0.07			
				Compact light brown sandy predominantly fine to medium gravel of sandstone (sub-base type materials) (MADE GROUND)		0.30			
0.50	D/J/V	D1		Soft to firm grey slightly organic sandy clay with occasional fine gravel and shale fragments. Recovered with a slightly organic odour (MADE GROUND)		(0.35)			
0.80	J	D2		Loose to medium dense brown-grey clayey sandy gravel of predominantly fine to medium subrounded to rounded quartzite (DISTURBED NATURAL STRATA)		0.65			
1.00 - 1.45	C		11			(0.55)			
				Loose to medium dense brown slightly clayey/silty SAND and GRAVEL. Sand predominantly medium to coarse grained and gravel predominantly fine to medium subrounded to rounded quartzite (HOLME PIERREPONT SAND AND GRAVEL)		1.20			
1.60	J	D3		...becoming wet and progressing into loose to medium dense sandy GRAVEL of fine to coarse subrounded to rounded quartzite below approximately 1.60m				▽	
2.00 - 2.45	C		10						
2.60	J	D4				(2.80)			
3.00 - 3.45	C		9						
				...with occasional bands of fine to coarse grained SAND with depth					
4.00 - 4.45	C		9	End of Borehole at 4.00m		4.00	4.00		

Remarks

1.Borehole cased to 4.00m. Sides collapsing below this depth.
2.Water encountered at approximately 1.60m.
3.Borehole backfilled with arisings on completion.

Key

D = Disturbed Sample
U = Undisturbed Sample
B = Bulk Sample
J = Jar Sample
V = Vial Sample
W = Water Sample
S = Standard Penetration Test (Split Spoon)
C = Standard Penetration Test (Cone)
▽ = Water Strike (m)
▼ = Steady Water Level (m)

Project:	Park House, Colwick			**Client:**	Radford Holdings Ltd		
Logged:	DH	**Checked:**	PA	**Field Book Ref:**	**Plant:**	Competitor Rig	**Drawing Ref:**
Date:	09/12/2022	**Approved:**	PA	DH 22/01	**Scale:**	1:25	WS4

GIA GROUND INVESTIGATION ASSOCIATES

WS5

Project No. 22121

Sheet 1 of 1

Samples and Tests				Description of Strata	Legend	Depth & (Thickness) (m)	Casing (m)	Ground-water	Installation
Depth (m)	Type	Sample Ref	SPT "N" Value						
				Macadam surfacing (MADE GROUND)		0.07			
				Compact light brown sandy gravel of fine to coarse angular to subangular sandstone (sub-base type materials) (MADE GROUND)		(0.31)			
				Soft to firm dark grey slightly organic sandy clay with occasional black carbonaceous inclusions (MADE GROUND)		0.38			
0.60	D/J	D1		Loose to medium dense brown clayey/silty predominantly fine to medium grained sand (MADE GROUND)		0.50			
						(0.45)			
1.00 - 1.45	C		10	Loose to medium dense dark brown clayey very gravelly sand. Gravel includes fine to medium subrounded to rounded quartzite (POSSIBLE REWORKED NATURAL STRATA)		0.95			
						(0.45)			
				Soft brown very sandy CLAY with rare fine to medium quartzite gravel (HOLME PIERREPONT SAND AND GRAVEL)		1.40			
				Loose to medium dense brown slightly clayey/silty SAND and GRAVEL. Sand predominantly medium to coarse grained and gravel predominantly fine to medium subrounded to rounded quartzite (HOLME PIERREPONT SAND AND GRAVEL)		1.55			
1.80	D/J	D2						▽	
2.00 - 2.45	C		10	...becoming wet at approximately 1.80m					
2.70	J	D3				(2.45)			
3.00 - 3.45	C		16						
				End of Borehole at 4.00m		4.00	4.00		

Remarks

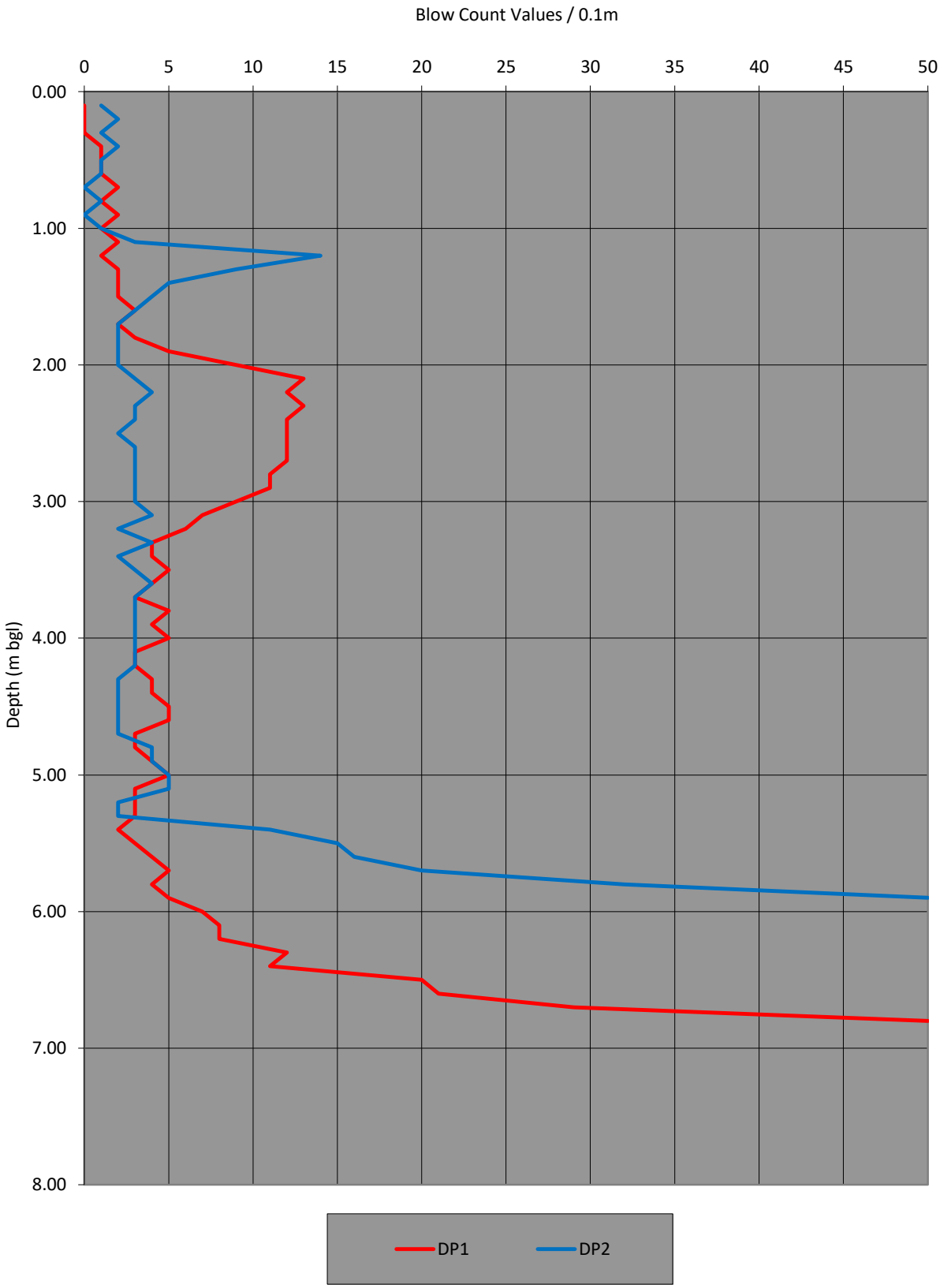
1.Borehole cased to 4.00m. Sides collapsing below this depth. Unable to take SPT at 4.00m as sampling tube stuck in casing.
2.Water encountered at approximately 1.80m.
3.Borehole backfilled with arisings on completion.

Key

D = Disturbed Sample
U = Undisturbed Sample
B = Bulk Sample
J = Jar Sample
V = Vial Sample
W = Water Sample
S = Standard Penetration Test (Split Spoon)
C = Standard Penetration Test (Cone)
▽ = Water Strike (m)
▼ = Steady Water Level (m)

Project:	Park House, Colwick			**Client:**	Radford Holdings Ltd		
Logged:	DH	**Checked:**	PA	**Field Book Ref:**	**Plant:**	Competitor Rig	**Drawing Ref:**
Date:	09/12/2022	**Approved:**	PA	DH 22/01	**Scale:**	1:25	WS5

Park House, Mile End Road, Colwick
DP1 and DP2 Dynamic Probe Results



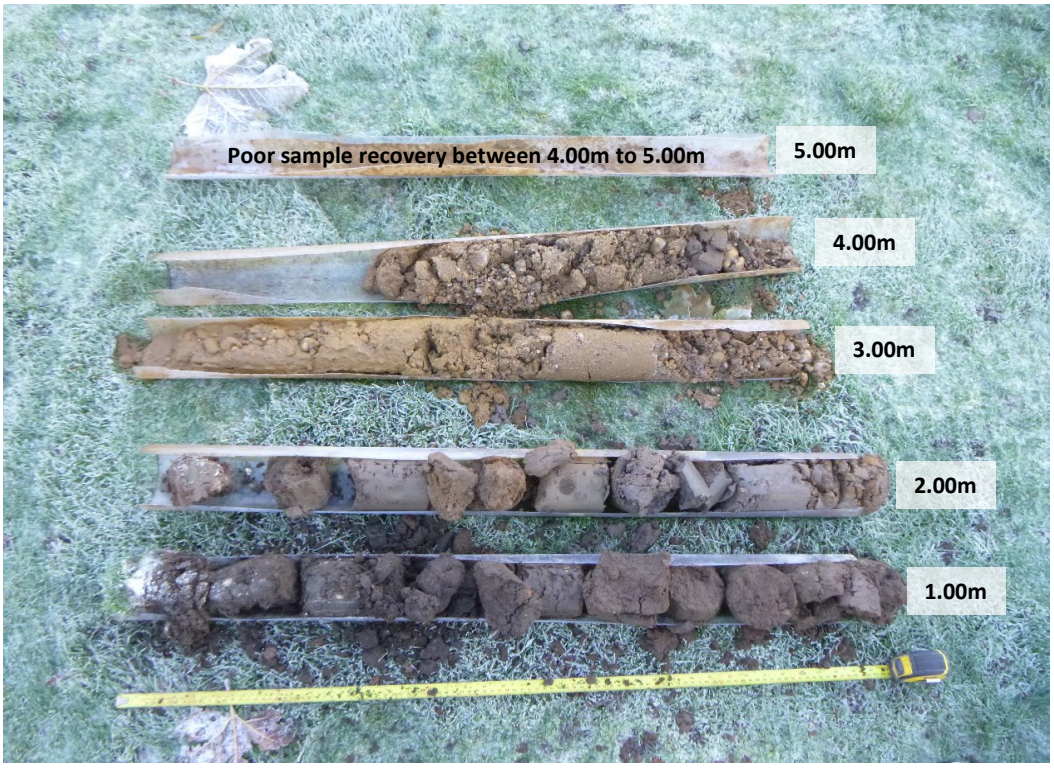
APPENDIX 5

Plates

GROUND INVESTIGATION ASSOCIATES

Web: www.giassociates.co.uk Email: office@giassociates.co.uk

Client Name:	Radford Holdings Ltd		
Project Name:	Park House, Mile End Road, Colwick		
Title:	Views of Borehole WS1 and WS2 Arisings		
Project Number:	22121	Drawn By:	DH
Date Drawn:	20/12/2022	Approved By:	PA
Plate No.	**P2-1**		



Title:	**Photograph Showing Arisings from WS1**

Title:	**Photograph Showing Arisings from WS2**

GIA GROUND INVESTIGATION ASSOCIATES

Web: www.giassociates.co.uk Email: office@giassociates.co.uk

Client Name:	Radford Holdings Ltd		
Project Name:	Park House, Mile End Road, Colwick		
Title:	Views of Borehole WS3 and WS4 Arisings		
Project Number:	22121	Drawn By:	DH
Date Drawn:	20/12/2022	Approved By:	PA
Plate No.	**P2-2**		

Title:	**Photograph Showing Arisings from WS3**

Title:	**Photograph Showing Arisings from WS4**

GIA GROUND INVESTIGATION ASSOCIATES

Web: www.giassociates.co.uk Email: office@giassociates.co.uk

Client Name:	Radford Holdings Ltd		
Project Name:	Park House, Mile End Road, Colwick		
Title:	Views of Borehole WS5 and Rig		
Project Number:	22121	Drawn By:	DH
Date Drawn:	20/12/2022	Approved By:	PA
Plate No.		**P2-3**	

Title:	**Photograph Showing Arisings from WS5**

Title:	**Photograph Showing Rig Set-up at WS4**

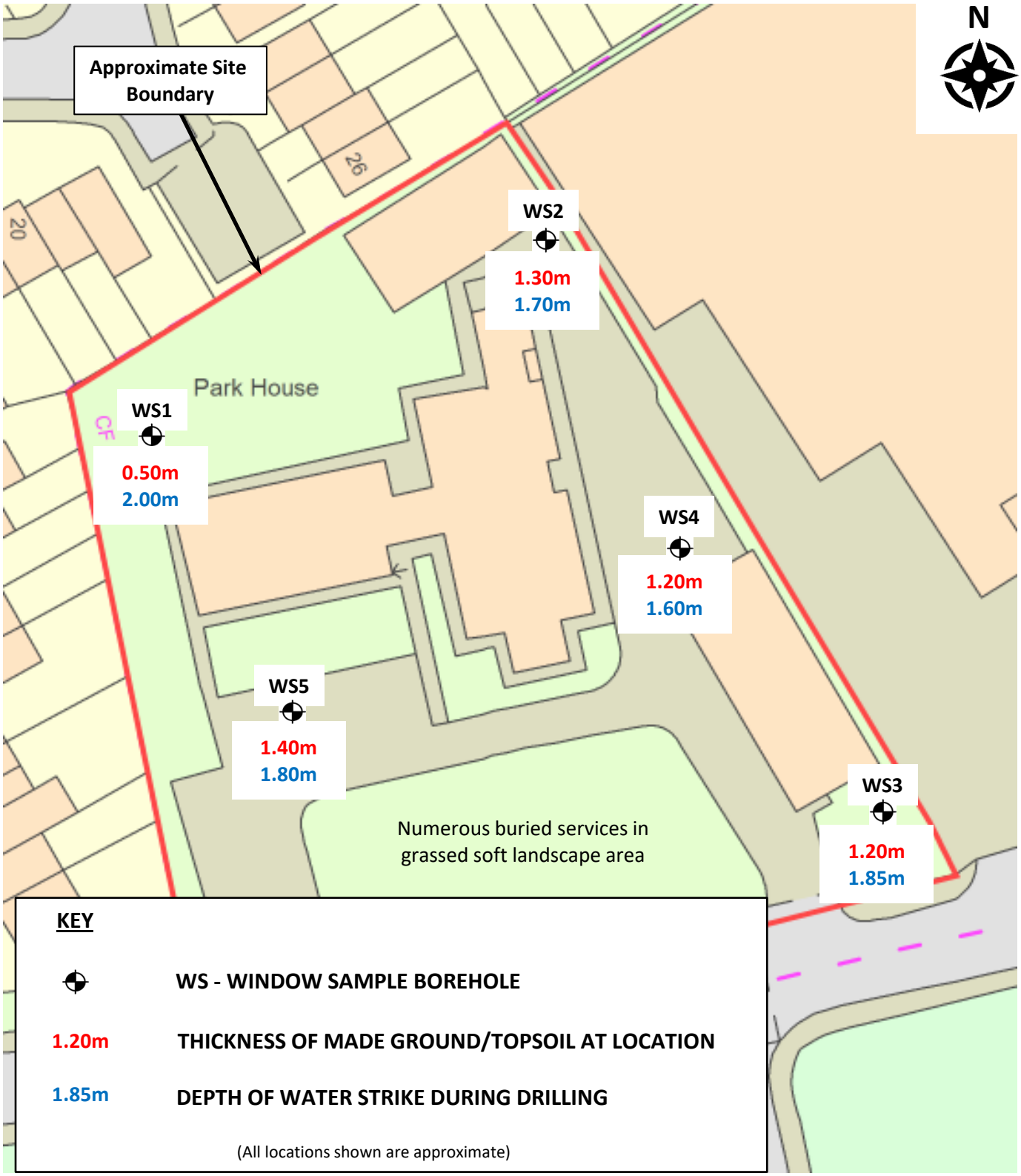
APPENDIX 6

Made Ground Thickness and Groundwater Strike Plan
(Drawing No. 22121-2/03)

GIA GROUND INVESTIGATION ASSOCIATES

Web: www.giassociates.co.uk Email: office@giassociates.co.uk

Client Name:	Radford Holdings Ltd		
Project Name:	Park House, Mile End Road, Colwick, Nottingham		
Title:	Made Ground Thicknesses & Water Strikes Plan		
Project Number:	22121	Drawn By:	PA
Date Drawn:	31/01/2023	Approved By:	DH
Drawing No.	**22121-2/03**		



APPENDIX 7

Ground Gas and Groundwater Data Sheets

Project No.	22121
Client	Radford Holdings Ltd
Site Location	Park House, Mile End Road, Colwick
Date	16/12/2022
Weather	Cold and clear (-4°C)
Equipment	GA5000, Tiger LT PID and dipmeter
Operator	DH

MONITORING OF SOIL GASES AND GROUNDWATER - IN ACCORDANCE WITH CIRIA C665 / BS8485:2015+A1:2019															
Borehole No.	Time (00:00)	Ambient Pressure (mb)		VOC (ppm IEU)	Methane (% v/v)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	CO (ppm)	H_2S (ppm)	Gas Flow (l/hr)	Depth to LNAPL (m begl)	Depth to groundwater (m begl)	Depth to DNAPL (m begl)	Time to steady readings (secs)	Other Issues i.e. odour, condition of installation, etc
WS1	08:35	1017	Peak	36.2	0.1	1.0	20.1	0	0	0.1	ND	2.02	ND	60	Monitored for 300 seconds.
			Steady	36.2	0.0	1.0	20.2	0	0	0.0					
WS2	08:47	1017	Peak	16.7	0.0	1.5	19.2	1	0	0.0	ND	1.68	ND	60	Monitored for 300 seconds.
			Steady	16.7	0.0	1.5	19.2	0	0	0.0					
WS3	09:01	1017	Peak	6.0	0.0	1.9	19.8	0	0	0.0	ND	1.89	ND	60	Monitored for 300 seconds.
			Steady	5.6	0.0	1.9	19.8	0	0	0.0					
Ambient		1017		NA	0.0	0.0	21.5	0	0						

Notes

Cell is highlighted in the following conditions

1. Where Methane exceeds 1% v/v (after BR212)
2. Where Carbon Dioxide exceeds 5% v/v (after BR212)
3. Where Carbon Monoxide exceeds 30ppm (after BS8576:2013)
4. Where Hydrogen Sulphide exceeds 5ppm (after BS8576:2013)
5. Where Oxygen is below 16% v/v (Coal Authority guidance)

Where cell is highlighted further consideration of the recorded value is required in accordance with the specified guidance documents

NA - Not Applicable/ Not Available

BOH - Bottom of Hole

ND - Not Determined

NGW - No groundwater encountered

NR - None Recorded

Project No.	22121
Client	Radford Holdings Ltd
Site Location	Park House, Mile End Road, Colwick
Date	21/12/2022
Weather	Clear and mild
Equipment	GA5000, Tiger LT PID and dipmeter
Operator	DH

MONITORING OF SOIL GASES AND GROUNDWATER - IN ACCORDANCE WITH CIRIA C665 / BS8485:2015+A1:2019															
Borehole No.	Time (00:00)	Ambient Pressure (mb)		VOC (ppm IEU)	Methane (% v/v)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	CO (ppm)	H_2S (ppm)	Gas Flow (l/hr)	Depth to LNAPL (m begl)	Depth to groundwater (m begl)	Depth to DNAPL (m begl)	Time to steady readings (secs)	Other Issues i.e. odour, condition of installation, etc
WS1	13:45	1001	Peak	2.5	0.0	1.0	19.8	0	0	0.0	ND	1.91	ND	60	Monitored for 300 seconds.
			Steady	2.5	0.0	1.0	19.9	0	0	0.0					
WS2	13:58	1001	Peak	3.2	0.0	1.7	18.6	0	0	0.0	ND	1.56	ND	60	Monitored for 300 seconds.
			Steady	3.2	0.0	1.7	18.7	0	0	0.0					
WS3	14:08	1001	Peak	1.1	0.0	1.8	19.9	0	0	0.0	ND	1.77	ND	60	Monitored for 300 seconds.
			Steady	0.7	0.0	1.8	19.9	0	0	0.0					
Ambient		1001		NA	0.0	0.0	21.2	0	0						

Notes

Cell is highlighted in the following conditions

1. Where Methane exceeds 1% v/v (after BR212)
2. Where Carbon Dioxide exceeds 5% v/v (after BR212)
3. Where Carbon Monoxide exceeds 30ppm (after BS8576:2013)
4. Where Hydrogen Sulphide exceeds 5ppm (after BS8576:2013)
5. Where Oxygen is below 16% v/v (Coal Authority guidance)

Where cell is highlighted further consideration of the recorded value is required in accordance with the specified guidance documents

NA - Not Applicable/ Not Available

BOH - Bottom of Hole

ND - Not Determined

NGW - No groundwater encountered

NR - None Recorded

Project No.	22121
Client	Radford Holdings Ltd
Site Location	Park House, Mile End Road, Colwick
Date	06/01/2023
Weather	Light cloud
Equipment	GA5000, Tiger LT PID and dipmeter
Operator	DH

MONITORING OF SOIL GASES AND GROUNDWATER - IN ACCORDANCE WITH CIRIA C665 / BS8485:2015+A1:2019															
Borehole No.	Time (00:00)	Ambient Pressure (mb)		VOC (ppm IEU)	Methane (% v/v)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	CO (ppm)	H_2S (ppm)	Gas Flow (l/hr)	Depth to LNAPL (m begl)	Depth to groundwater (m begl)	Depth to DNAPL (m begl)	Time to steady readings (secs)	Other Issues i.e. odour, condition of installation, etc
WS1	09:26	1011	Peak	0.1	0.0	1.1	20.1	0	0	0.0	ND	1.77	ND	30	Monitored for 300 seconds.
			Steady	0.0	0.0	1.1	20.1	0	0	0.0					
WS2	09:38	1011	Peak	0.3	0.0	2.1	18.6	0	0	0.0	ND	1.42	ND	60	Monitored for 300 seconds.
			Steady	0.1	0.0	2.1	18.7	0	0	0.0					
WS3	09:49	1011	Peak	0.2	0.0	1.6	20.8	0	0	0.0	ND	1.62	ND	60	Monitored for 300 seconds.
			Steady	0.0	0.0	1.6	20.8	0	0	0.0					
Ambient		1011		NA	0.0	0.0	21.3	0	0						

Notes

Cell is highlighted in the following conditions

1. Where Methane exceeds 1% v/v (after BR212)
2. Where Carbon Dioxide exceeds 5% v/v (after BR212)
3. Where Carbon Monoxide exceeds 30ppm (after BS8576:2013)
4. Where Hydrogen Sulphide exceeds 5ppm (after BS8576:2013)
5. Where Oxygen is below 16% v/v (Coal Authority guidance)

Where cell is highlighted further consideration of the recorded value is required in accordance with the specified guidance documents

NA - Not Applicable/ Not Available

BOH - Bottom of Hole

ND - Not Determined

NGW - No groundwater encountered

NR - None Recorded

Project No.	22121
Client	Radford Holdings Ltd
Site Location	Park House, Mile End Road, Colwick
Date	20/01/2023
Weather	Cold (2°C)
Equipment	GA5000, Tiger LT PID and dipmeter
Operator	DH

MONITORING OF SOIL GASES AND GROUNDWATER - IN ACCORDANCE WITH CIRIA C665 / BS8485:2015+A1:2019															
Borehole No.	Time (00:00)	Ambient Pressure (mb)		VOC (ppm IEU)	Methane (% v/v)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	CO (ppm)	H_2S (ppm)	Gas Flow (l/hr)	Depth to LNAPL (m begl)	Depth to groundwater (m begl)	Depth to DNAPL (m begl)	Time to steady readings (secs)	Other Issues i.e. odour, condition of installation, etc
WS1	09:30	1018	Peak	0.0	0.0	1.2	20.4	0	0	0.1	ND	1.84	ND	60	Monitored for 300 seconds.
			Steady	0.0	0.0	1.1	20.6	0	0	0.0					
WS2	09:42	1018	Peak	0.1	0.0	2.0	19.0	0	0	0.0	ND	1.48	ND	30	Monitored for 300 seconds.
			Steady	0.0	0.0	2.0	19.0	0	0	0.0					
WS3	09:52	1018	Peak	0.0	0.0	1.4	20.5	0	0	0.0	ND	1.69	ND	60	Monitored for 300 seconds.
			Steady	0.0	0.0	1.4	20.5	0	0	0.0					
Ambient		1018		NA	0.0	0.0	21.5	0	0						

Notes

Cell is highlighted in the following conditions

1. Where Methane exceeds 1% v/v (after BR212)
2. Where Carbon Dioxide exceeds 5% v/v (after BR212)
3. Where Carbon Monoxide exceeds 30ppm (after BS8576:2013)
4. Where Hydrogen Sulphide exceeds 5ppm (after BS8576:2013)
5. Where Oxygen is below 16% v/v (Coal Authority guidance)

Where cell is highlighted further consideration of the recorded value is required in accordance with the specified guidance documents

NA - Not Applicable/ Not Available

BOH - Bottom of Hole

ND - Not Determined

NGW - No groundwater encountered

NR - None Recorded

APPENDIX 8

Laboratory Soil Test Results

Eurofins Chemtest Ltd
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	22-47907-1		
Initial Date of Issue:	15-Jan-2023		
Client	GIA (Ground Investigation Associates Ltd)		
Client Address:	49 High Street Hucknall Nottingham NG15 7AW		
Contact(s):	Dave Hooton Phil Anelay		
Project	22121 Park House, Colwick		
Quotation No.:	Q21-23852	**Date Received:**	14-Dec-2022
Order No.:	22121/GIA/DH	**Date Instructed:**	14-Dec-2022
No. of Samples:	9		
Turnaround (Wkdays):	10	**Results Due:**	03-Jan-2023
Date Approved:	15-Jan-2023		

Approved By:

Details: Stuart Henderson, Technical Manager

Results - Soil

Project: 22121 Park House, Colwick

Client: GIA (Ground Investigation Associates Ltd)		Chemtest Job No.:			22-47907	22-47907	22-47907	22-47907	22-47907	22-47907	22-47907	22-47907	22-47907
Quotation No.: Q21-23852		Chemtest Sample ID.:			1564471	1564472	1564474	1564475	1564477	1564478	1564480	1564482	1564484
		Client Sample ID.:			D1	D2	D1	D2	D1	D2	D1	D3	D1
		Sample Location:			WS1	WS1	WS2	WS2	WS3	WS3	WS4	WS4	WS5
		Sample Type:			SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
		Top Depth (m):			0.30	0.80	0.50	1.60	0.40	1.60	0.50	1.60	0.60
		Date Sampled:			09-Dec-2022	09-Dec-2022	09-Dec-2022	09-Dec-2022	09-Dec-2022	09-Dec-2022	09-Dec-2022	09-Dec-2022	09-Dec-2022
		Asbestos Lab:					NEW-ASB		NEW-ASB		NEW-ASB		
Determinand	**Accred.**	**SOP**	**Units**	**LOD**									
ACM Type	U	2192		N/A			-		-		-		
Asbestos Identification	U	2192		N/A			No Asbestos Detected		No Asbestos Detected		No Asbestos Detected		
Moisture	N	2030	%	0.020	10	12	22	5.9	12	4.2	15	8.3	5.3
Soil Colour	N	2040		N/A	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown
Other Material	N	2040		N/A	Stones and Roots	Stones	Stones and Roots	Stones	Stones and Roots	Stones	Stones	Stones	Stones
Soil Texture	N	2040		N/A	Loam	Loam	Loam	Sand	Loam	Sand	Clay	Sand	Sand
pH	M	2010		4.0	7.2	7.5	7.3		7.8	7.3	7.1	7.3	6.4
Sulphate (2:1 Water Soluble) as SO4	M	2120	g/l	0.010		< 0.010				0.043		< 0.010	< 0.010
Arsenic	M	2455	mg/kg	0.5	11	8.8	15		11		8.3	6.7	
Cadmium	M	2455	mg/kg	0.10	0.98	1.0	1.3		0.98		0.66	0.34	
Chromium	M	2455	mg/kg	0.5	20	20	33		23		18	9.7	
Copper	M	2455	mg/kg	0.50	36	22	27		26		18	10	
Mercury	M	2455	mg/kg	0.05	0.10	< 0.05	0.07		0.05		< 0.05	< 0.05	
Nickel	M	2455	mg/kg	0.50	20	22	30		26		20	15	
Lead	M	2455	mg/kg	0.50	80	47	85		89		48	14	
Selenium	M	2455	mg/kg	0.25	1.1	0.95	1.9		1.2		1.1	0.44	
Zinc	M	2455	mg/kg	0.50	140	140	200		150		110	38	
Chromium (Trivalent)	N	2490	mg/kg	1.0	20	20	33		23		18	9.7	
Chromium (Hexavalent)	N	2490	mg/kg	0.50	< 0.50	< 0.50	< 0.50		< 0.50		< 0.50	< 0.50	
Aliphatic VPH >C5-C6	N	2780	mg/kg	0.05				< 0.05		< 0.05	< 0.05		
Aliphatic VPH >C6-C7	N	2780	mg/kg	0.05				< 0.05		< 0.05	< 0.05		
Aliphatic VPH >C7-C8	N	2780	mg/kg	0.05				< 0.05		< 0.05	< 0.05		
Aliphatic VPH >C8-C10	N	2780	mg/kg	0.05				< 0.05		< 0.05	< 0.05		
Total Aliphatic VPH >C5-C10	N	2780	mg/kg	0.25				< 0.25		< 0.25	< 0.25		
Aliphatic EPH >C10-C12	N	2690	mg/kg	2.00				< 2.0		< 2.0	< 2.0		
Aliphatic EPH >C12-C16	N	2690	mg/kg	1.00				< 1.0		< 1.0	< 1.0		
Aliphatic EPH >C16-C21	N	2690	mg/kg	2.00				< 2.0		< 2.0	< 2.0		
Aliphatic EPH >C21-C35	N	2690	mg/kg	3.00				< 3.0		< 3.0	< 3.0		
Aliphatic EPH >C35-C40	N	2690	mg/kg	1.00				< 1.0		< 1.0	< 1.0		
Total Aliphatic EPH >C10-C35	N	2690	mg/kg	5.00				< 5.0		< 5.0	< 5.0		
Aromatic VPH >C5-C7	N	2780	mg/kg	0.05				< 0.05		< 0.05	< 0.05		
Aromatic VPH >C7-C8	N	2780	mg/kg	0.05				< 0.05		< 0.05	< 0.05		
Aromatic VPH >C8-C10	N	2780	mg/kg	0.05				< 0.05		< 0.05	< 0.05		
Total Aromatic VPH >C5-C10	N	2780	mg/kg	0.25				< 0.25		< 0.25	< 0.25		
Aromatic EPH >C10-C12	N	2690	mg/kg	1.00				< 1.0		< 1.0	< 1.0		

Results - Soil

Project: 22121 Park House, Colwick

Client: GIA (Ground Investigation Associates Ltd)					Chemtest Job No.:	22-47907	22-47907	22-47907	22-47907	22-47907	22-47907	22-47907	22-47907	22-47907
Quotation No.: Q21-23852					Chemtest Sample ID.:	1564471	1564472	1564474	1564475	1564477	1564478	1564480	1564482	1564484
					Client Sample ID.:	D1	D2	D1	D2	D1	D2	D1	D3	D1
					Sample Location:	WS1	WS1	WS2	WS2	WS3	WS3	WS4	WS4	WS5
					Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
					Top Depth (m):	0.30	0.80	0.50	1.60	0.40	1.60	0.50	1.60	0.60
					Date Sampled:	09-Dec-2022	09-Dec-2022	09-Dec-2022	09-Dec-2022	09-Dec-2022	09-Dec-2022	09-Dec-2022	09-Dec-2022	09-Dec-2022
					Asbestos Lab:			NEW-ASB		NEW-ASB		NEW-ASB		
Determinand	**Accred.**	**SOP**	**Units**	**LOD**										
Aromatic EPH >C12-C16	N	2690	mg/kg	1.00					< 1.0		< 1.0	< 1.0		
Aromatic EPH >C16-C21	N	2690	mg/kg	2.00					230		260	160		
Aromatic EPH >C21-C35	N	2690	mg/kg	2.00					< 2.0		< 2.0	< 2.0		
Aromatic EPH >C35-C40	N	2690	mg/kg	1.00					< 1.0		1.1	< 1.0		
Total Aromatic EPH >C10-C35	N	2690	mg/kg	5.00					230		260	160		
Total VPH >C5-C10	N	2780	mg/kg	0.50					< 0.50		< 0.50	< 0.50		
Total EPH >C10-C35	N	2690	mg/kg	10.00					230		260	160		
Total Organic Carbon	M	2625	%	0.20	2.2	0.64	1.6		1.1		2.7	< 0.20		
Naphthalene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		0.35		< 0.10	< 0.10		
Acenaphthylene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		0.18		< 0.10	< 0.10		
Acenaphthene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		0.34		< 0.10	< 0.10		
Fluorene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		0.12		< 0.10	< 0.10		
Phenanthrene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		0.76		< 0.10	< 0.10		
Anthracene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		0.14		< 0.10	< 0.10		
Fluoranthene	M	2700	mg/kg	0.10	0.48	< 0.10	< 0.10		1.3		< 0.10	< 0.10		
Pyrene	M	2700	mg/kg	0.10	0.74	< 0.10	< 0.10		1.5		< 0.10	< 0.10		
Benzo[a]anthracene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		0.50		< 0.10	< 0.10		
Chrysene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		0.90		< 0.10	< 0.10		
Benzo[b]fluoranthene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		1.2		< 0.10	< 0.10		
Benzo[k]fluoranthene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		0.38		< 0.10	< 0.10		
Benzo[a]pyrene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		0.71		< 0.10	< 0.10		
Indeno(1,2,3-c,d)Pyrene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		< 0.10		< 0.10	< 0.10		
Dibenz(a,h)Anthracene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		< 0.10		< 0.10	< 0.10		
Benzo[g,h,i]perylene	M	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10		< 0.10		< 0.10	< 0.10		
Total Of 16 PAH's	M	2700	mg/kg	2.0	< 2.0	< 2.0	< 2.0		8.4		< 2.0	< 2.0		
Benzene	M	2760	µg/kg	1.0				< 1.0		< 1.0	< 1.0			
Toluene	M	2760	µg/kg	1.0				< 1.0		< 1.0	< 1.0			
Ethylbenzene	M	2760	µg/kg	1.0				< 1.0		< 1.0	< 1.0			
m & p-Xylene	M	2760	µg/kg	1.0				< 1.0		< 1.0	< 1.0			
o-Xylene	M	2760	µg/kg	1.0				< 1.0		< 1.0	< 1.0			
Methyl Tert-Butyl Ether	M	2760	µg/kg	1.0				< 1.0		< 1.0	< 1.0			

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2040	Soil Description(Requirement of MCERTS)	Soil description	As received soil is described based upon BS5930
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2192	Asbestos	Asbestos	Polarised light microscopy / Gravimetry
2455	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2690	EPH A/A Split	Aliphatics: >C10–C12, >C12–C16, >C16–C21, >C21– C35, >C35– C40 Aromatics: >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C40	Acetone/Heptane extraction / GCxGC FID detection
2700	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-FID	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Dichloromethane extraction / GC-FID (GC-FID detection is non-selective and can be subject to interference from co-eluting compounds)
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2780	VPH A/A Split	Aliphatics: >C5–C6, >C6–C7,>C7–C8,>C8-C10 Aromatics: >C5–C7,>C7-C8,>C8–C10	Water extraction / Headspace GCxGC FID detection

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
SOP	Standard operating procedure
LOD	Limit of detection

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 30 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

LABORATORY REPORT

4043

Contract Number: PSL22/7968

Report Date: 04 January 2023

Client's Reference: 22121

Client Name: Ground Investigation Associates
49 High Street
Hucknall
Nottingham
NG15 7AW

For the attention of: Dave Hooton

Contract Title: Park House, Colwick

Date Received: 15/12/2022
Date Commenced: 15/12/2022

A copy of the Laboratory Schedule of accredited tests as issued by UKAS is attached to this report. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced other than in full, without the prior written approval of the laboratory.

Checked and Approved Signatories:

A Watkins
(Director)

R Berriman
(Quality Manager)

S Royle
(Laboratory Manager)

L Knight
(Assistant Laboratory Manager)

S Eyre
(Senior Technician)

M Fennell
(Senior Technician)

5 – 7 Hexthorpe Road, Hexthorpe,
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awatkins@prosoils.co.uk

SUMMARY OF LABORATORY SOIL DESCRIPTIONS

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Description of Sample
WS1	1	B	1.30	1.80	Brown very sandy CLAY.
WS2	1	B	1.30	2.00	Brown very sandy slightly silty GRAVEL.
WS3	-	B	2.00	3.00	Brown very sandy slightly silty GRAVEL.

UKAS TESTING
4043

PSL
Professional Soils Laboratory

Park House, Colwick

Contract No:
PSL22/7968
Client Ref:
22121

SUMMARY OF SOIL CLASSIFICATION TESTS

(BS1377 : PART 2 : 1990)

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Moisture Content % Clause 3.2	Linear Shrinkage % Clause 6.5	Particle Density Mg/m^3 Clause 8.2	Liquid Limit % Clause 4.3/4	Plastic Limit % Clause 5.3	Plasticity Index % Clause 5.4	Passing .425mm %	Remarks
WS1	1	B	1.30	1.80	17			25	14	11	100	Low Plasticity CL

SYMBOLS : **NP : Non Plastic** *** : Liquid Limit and Plastic Limit Wet Sieved.**

UKAS TESTING 4043

PSL Professional Soils Laboratory

Park House, Colwick

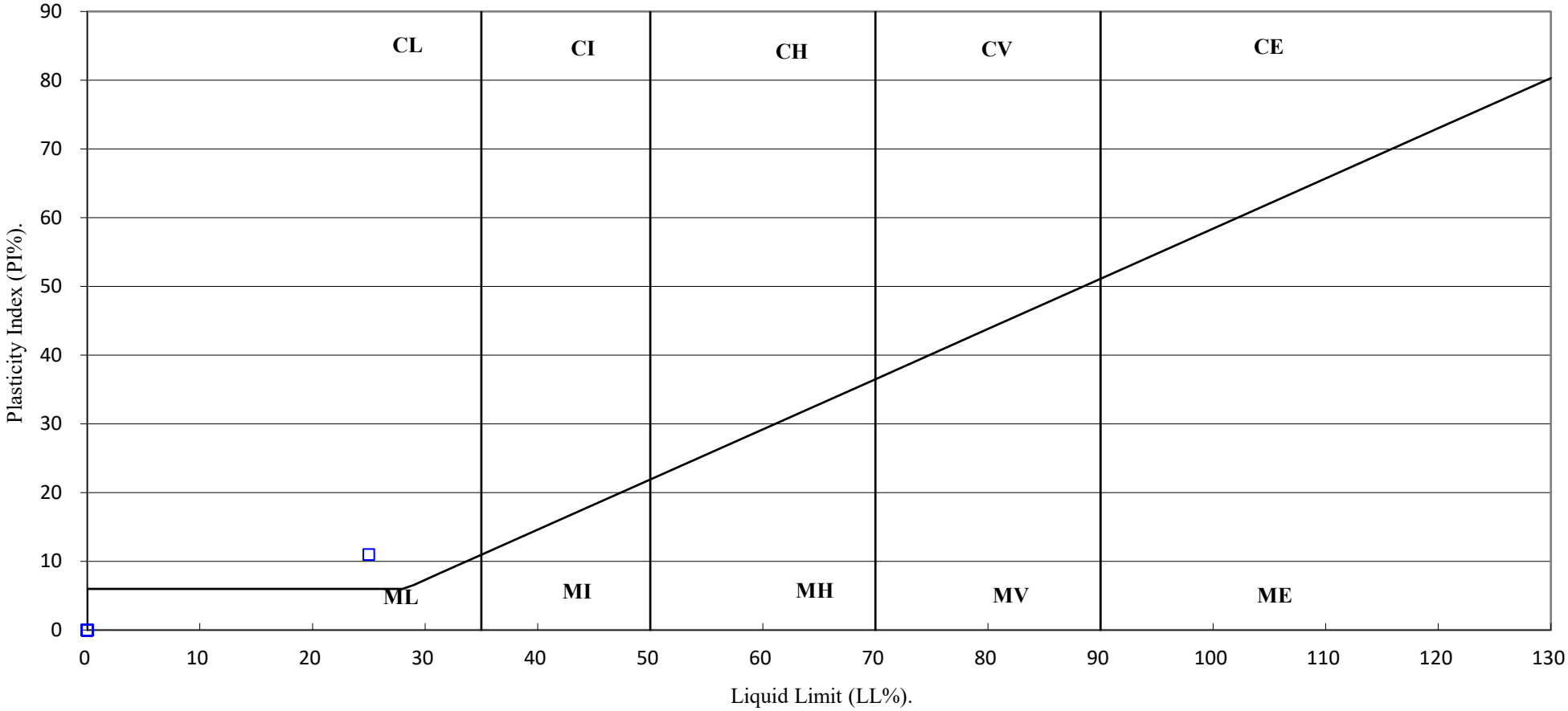
Contract No:

PSL22/7968

Client Ref:

22121

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.



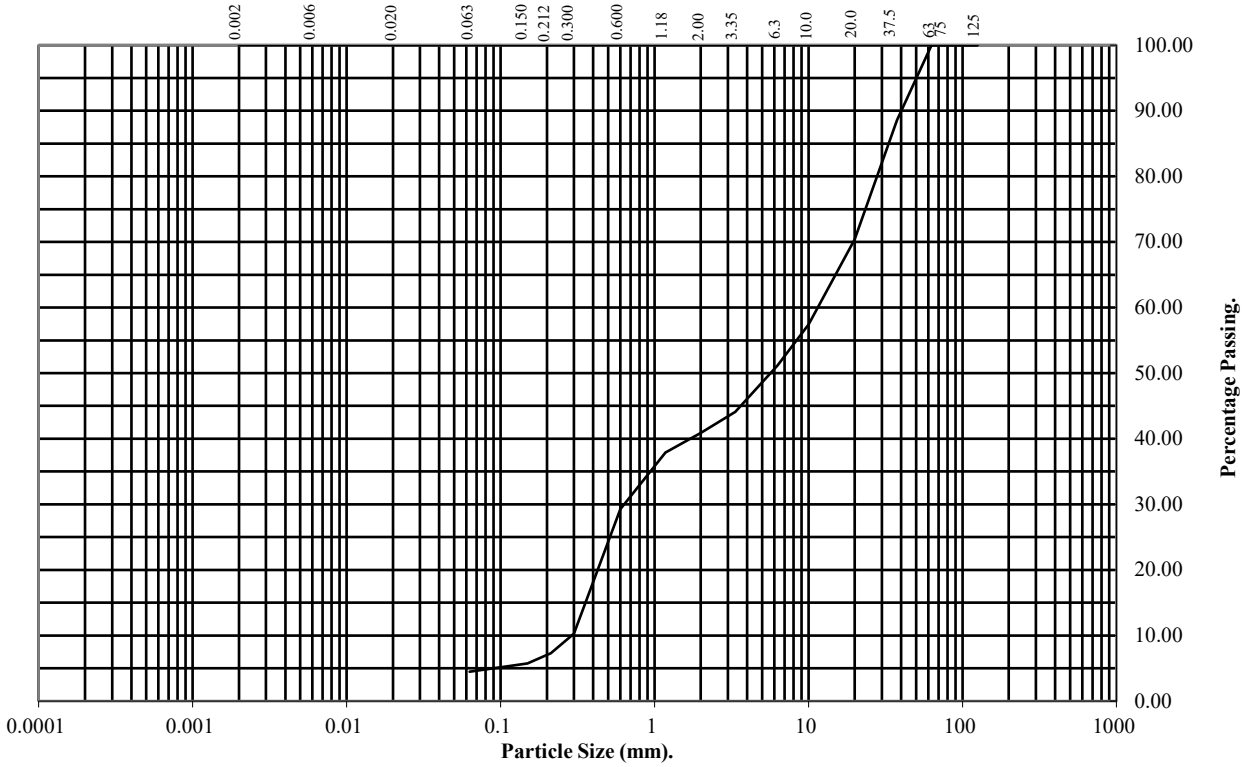
UKAS TESTING 4043	PSL Professional Soils Laboratory	Park House, Colwick	Contract No: PSL22/7968 Client Ref: 22121

PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

Hole Number:	**WS2**	**Top Depth (m):**	**1.30**
Sample Number:	**1**	**Base Depth(m):**	**2.00**
Sample Type:	**B**		



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	89
20	70
10	57
6.3	51
3.35	44
2	41
1.18	38
0.6	29
0.3	10
0.212	7
0.15	6
0.063	4

Soil Fraction	Total Percentage
Cobbles	0
Gravel	59
Sand	37
Silt/Clay	4

Remarks:

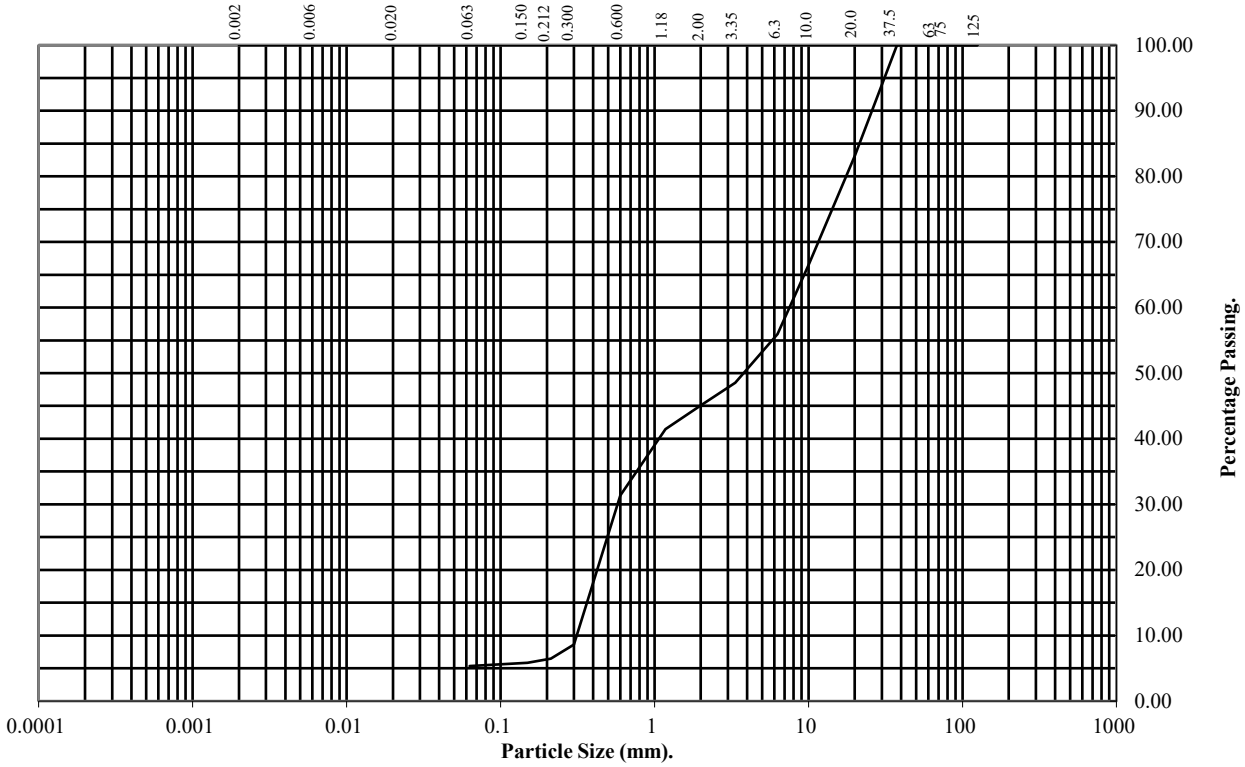
See Summary of Soil Descriptions

PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

Hole Number:	**WS3**	**Top Depth (m):**	**2.00**
Sample Number:	**-**	**Base Depth(m):**	**3.00**
Sample Type:	**B**		



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	83
10	66
6.3	56
3.35	49
2	45
1.18	41
0.6	31
0.3	9
0.212	6
0.15	6
0.063	5

Soil Fraction	Total Percentage
Cobbles	0
Gravel	55
Sand	40
Silt/Clay	5

Remarks:

See Summary of Soil Descriptions

APPENDIX 9

GIA Calculation Sheets

Project No.	22121-2
Client	Radford Holdings Ltd
Site Location	Park House, Mile End Road, Colwick
Comments	Individual boreholes Qhg assessment
Engineer	DH

BOREHOLE HAZARDOUS GAS ASSESSMENT (Qhg)

BH Ref	Date	Pressure (mb)	GW Level (m begl)	Peak Methane (% by vol)	Peak Carbon Dioxide (% by vol)	Minimum Oxygen (% by vol)	Steady +ve Flow Rate (l/hr)	Qhg (l/hr) Methane	Qhg (l/hr) CO2	Equivalent Characteristic Situation based on Qhg only	Notes
WS1	16.12.22	1017	2.02	0.1	1.0	20.1	0.0	0.0001	0.0010	CS1	
	21.12.22	1001	1.91	0.0	1.0	19.8	0.0	0.0000	0.0010	CS1	
	06.01.23	1011	1.77	0.0	1.1	20.1	0.0	0.0000	0.0011	CS1	
	20.01.23	1018	1.84	0.0	1.2	20.4	0.0	0.0000	0.0012	CS1	
WORST CASE WS1				**0.1**	**1.2**		**0.0**	**0.0001**	**0.0012**	**CS1**	
WS2	16.12.22	1017	1.68	0.0	1.5	19.2	0.0	0.0000	0.0015	CS1	
	21.12.22	1001	1.56	0.0	1.7	18.6	0.0	0.0000	0.0017	CS1	All wells retained viability during spot monitoring exercise
	06.01.23	1011	1.42	0.0	2.1	18.6	0.0	0.0000	0.0021	CS1	
	20.01.23	1018	1.48	0.0	2.0	19.0	0.0	0.0000	0.0020	CS1	
WORST CASE WS2				**0.0**	**2.1**		**0.0**	**0.0000**	**0.0021**	**CS1**	
WS3	16.12.22	1017	1.89	0.0	1.9	19.8	0.0	0.0000	0.0019	CS1	
	21.12.22	1001	1.77	0.0	1.8	19.9	0.0	0.0000	0.0018	CS1	
	06.01.23	1011	1.62	0.0	1.6	20.8	0.0	0.0000	0.0016	CS1	
	20.01.23	1018	1.69	0.0	1.4	20.5	0.0	0.0000	0.0014	CS1	
WORST CASE WS3				**0.0**	**1.9**		**0.0**	**0.0000**	**0.0019**	**CS1**	

	Max CH4	Max CO2	Max Flow	GSV CH4	GSV CO2	Worst Case CS
WORST CASE GSV CHECK	0.1	2.1	0.0	0.0001	0.0021	**CS1**

Notes

NGW - No Groundwater encountered

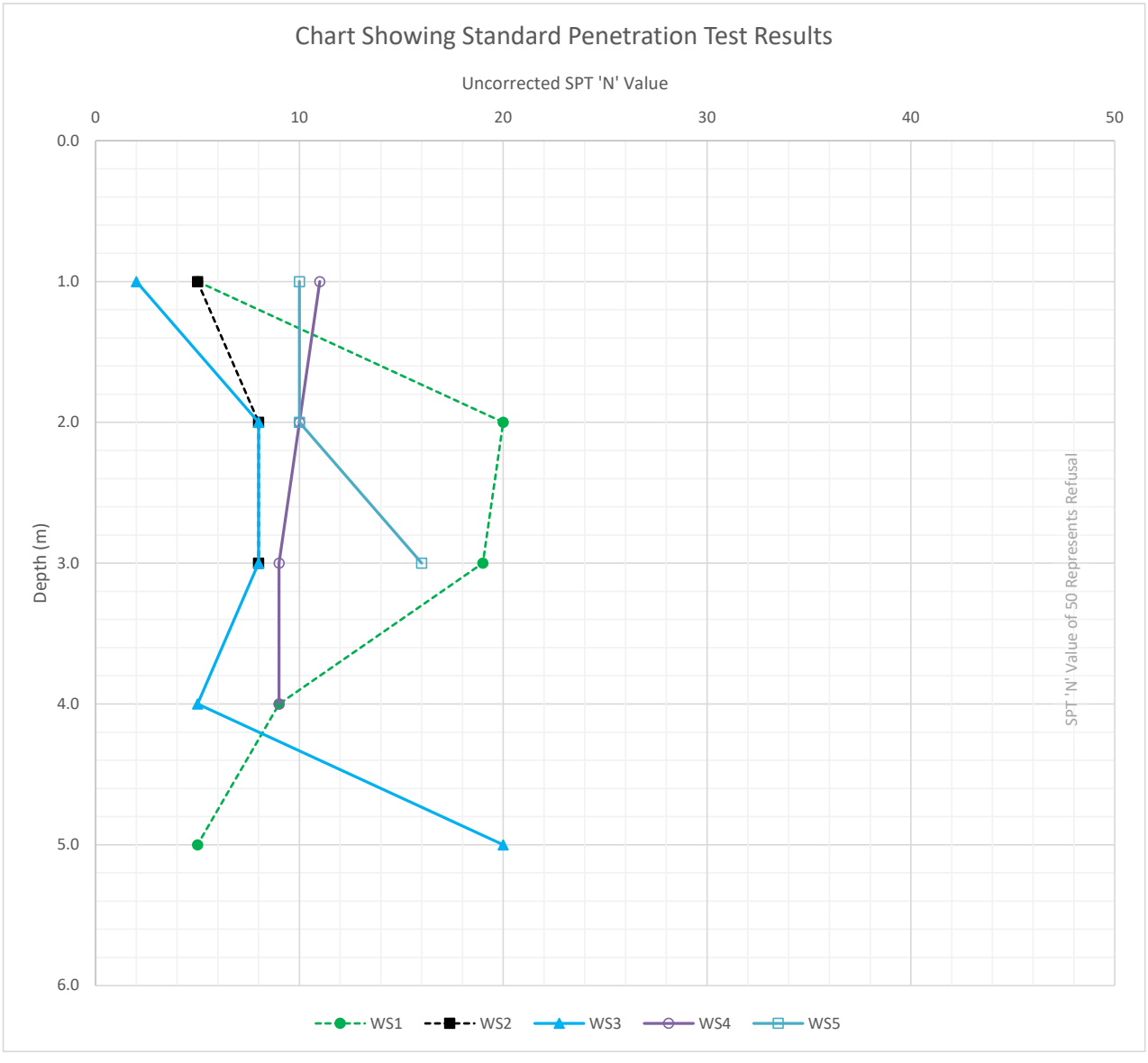
Cell is highlighted in the following conditions:

1. Where Methane exceeds 1% v/v (consider increasing to CS2)
2. Where Carbon Dioxide exceeds 5% v/v (consider increasing to CS2)

Where <0.1 l/hr flow recorded 0.1 l/hr adopted in calculation

Client Name:	Radford Holdings Ltd		
Project Name:	Park House, Mile End Road, Colwick		
Title:	SPT Data and Chart		
Project No:	22121	Created By:	DH
Drilling Rig:	RP04	Approved By:	PA

Depth (m)	WS1	WS2	WS3	WS4	WS5				
1.0	5	5	2	11	10				
2.0	20	8	8	10	10				
3.0	19	8	8	9	16				
4.0	9		5	9					
5.0	5		20						
Note	Indicative presentation only.								



APPENDIX 10

GIA Risk Assessment Methodology Sheets

A1 RISK ASSESSMENT METHODOLOGY FOR CONCEPTUAL SITE MODELS

A1.1 Conceptual Site Models (CSMs)

In order to convey the key geo-environmental issues pertaining to a particular site, based on the engineering judgement of the individual preparing the assessment, the use of a Conceptual Site Model (CSM) is widely adopted. The CSM identifies the potential sources of contamination present at a site (i.e. hazards), identifies the potential exposure mechanisms applicable to the identified possible contaminant source(s) and identifies the receptors plausibly affected by any contamination. Together, this is known as the Source-Pathway-Receptor model and informs the likelihood of a contaminant linkage being present.

The production of a CSM is undertaken as an iterative process, where the CSM is updated following acquisition of additional site-specific information and following resolution of identified uncertainties. As noted in BS EN ISO 21365:2020 '*Soil quality – Conceptual site models for potentially contaminated sites*': '*The complexity of a CSM should be consistent with the complexity of the site and available data and the purpose for which it is developed.*'

A1.2 Preliminary and Revised CSMs

Preliminary CSMs (pCSMs) are initially derived at the Phase 1 Desk Study stage and aim to identify the key plausible contaminant linkages potentially applicable to a given site. The derivation of these plausible linkages should take account of the uncertainties associated primarily with reliance on literature and desk based information, and are generally refined following acquisition of site-specific information following ground investigation works.

In order to provide an initial risk assessment and qualitative appraisal of the identified plausible contaminant linkages, consideration of the following is required:

- The probability/likelihood of the linkage occurring (See A1.3);
- The severity of the potential consequences of the contaminant linkage (see A1.4);
- The receptor sensitivity within the context of the proposed end use (See A1.5).

Unless otherwise stated in the Objectives section of our report, consideration of the plausible contaminant linkages has been undertaken in the context of the planning regime (i.e. in consideration of the requirements of the National Planning Policy Framework document).

Where the pCSM identifies the requirement for further consideration of one or more plausible contaminant linkages, further lines of evidence are required to provide additional context and clarity over the linkage components. The collation and collection of this additional information is subsequently used to refine the existing linkages detailed within the pCSM, with the refinement(s) detailed within a Revised CSM.

The CSM should be updated after each phase of investigation (i.e. Exploratory, Main or Supplementary Phases as detailed within BS10175:2011+A2:2017 '*Investigation of potentially contaminated sites. Code of practice*').

A1.3 Assessment of Probability/Likelihood

In determining the terminology used in informing the classification of probability applicable to an identified plausible contaminant linkage, GIA has made reference to CIRIA C552 '*Contaminated Land Risk Assessment, A Guide to Good Practice*', 2001 and EA R&D publication 66 '*Guidance for the Safe Development of Housing on Land Affected by Contamination*', 2008.

Table A1-1 details the terms and definitions used in the production of a CSM.

TABLE A1-1 – TERMS USED FOR THE ASSESSMENT OF PROBABILITY

Classification	Definition	Likelihood
High Likelihood	There is a pollutant linkage and an event is highly likely to occur in the short-term, and is almost inevitable over the long-term OR there is evidence at the receptor of harm or pollution occurring.	>95% likelihood of Consequence Occurring
Likely	There is a pollutant linkage and it is probable that an event will occur. It is not inevitable, but possible in the short-term and likely over the long-term.	50 – 95% likelihood of Consequence Occurring
Low Likelihood	There is a pollutant linkage and circumstances are possible under which an event could occur. It is by no means certain that even over a longer period such an event would take place, and less likely in the short-term.	5 – 49% Likelihood of Consequence Occurring
Unlikely	There is a pollutant linkage and it is improbable that an event would occur even in the very long-term.	<5% likelihood of Consequence Occurring

It should be noted that only plausible contaminant linkages should be included within a CSM. Where there is no plausible source, pathway or receptor applicable to a contaminant linkage, these should be detailed prior to the CSM being prepared.

A1.4 Assessment of Severity

GIA has utilised the definitions of consequence severity detailed within the CIRIA C552 document. These are detailed in Table A1-2 below.

TABLE A1-2 – TERMS USED FOR THE ASSESSMENT OF SEVERITY	
Term	**Definition**
Severe	• Acute risks to human health. • Short-term risk of pollution of controlled waters or significant impact on controlled waters; e.g. large-scale pollution or very high levels of contamination. • Catastrophic damage to buildings or property (such as building explosion causing collapse). • Ecological system effects – immediate risks of major damage which is likely to result in irreversible substantial adverse changes in the functioning of the ecosystem or harm to a species of special interest that endangers the long-term maintenance of the population.
Medium	• Chronic risks to human health. • Pollution of sensitive water resources (such as leaching of contaminants into controlled waters) causing a significant effect on water quality. • Ecological system effects – Immediate risks of significant damage which may result in substantial adverse changes to the ecosystems functioning or harm to a species of special interest that may endanger the long-term maintenance of the population. • Significant damage to buildings, structures and services (for example foundation damage or rendering the building unsuitable for habitation).
Mild	• Non-permanent health effects to human health (i.e. exposure is unlikely to lead to 'significant harm' in the context of Part 2A of the Environmental Protection Act 1990). • Pollution of controlled waters or non-sensitive water resources (for example non-classified groundwater) that results in a short-lived effect to water quality or a marginal effect on amenity value, agriculture or commerce. • Minor damage to buildings, structures and services. • Ecological system effects – Minor or short-term damage which is unlikely to result in substantial adverse changes to the ecosystems functioning or harm to a species of special interest. • Substantial damage to non-sensitive environments (such as arable farmland for example).
Minor	• No measurable effects on human health including non-permanent health effects to human health that are easily preventable by appropriate use of PPE/RPE. • Minor pollution of controlled waters including non-sensitive water resources with no discernible effects on water quality or ecosystems. • Minor damage to non-sensitive environments (including arable farmland for example). • Easily repairable effects of damage to buildings, structures, services or the environment (for example discolouration of concrete, loss of plants in a landscaping scheme etc.).

A1.5 Risk Classification

Once the engineering judgment assessment of probability and severity has been provided based on the information available, overall risk associated with that plausible contaminant linkage can be established. The terms detailed in Tables A1-3 and A1-4 have been used by GIA, which are largely based on those provided within CIRIA C552.

TABLE A1-3 - RISK MATRIX				
Classification	**Consequence of Risk**			
	Severe	Medium	Mild	Minor
High Likelihood	**Very High**	**High**	**Moderate**	**Moderate/Low**
Likely	**High**	**Moderate**	**Moderate/Low**	**Low**
Low Likelihood	**Moderate**	**Moderate/Low**	**Low**	**Negligible**
Unlikely	**Moderate/Low**	**Low**	**Negligible**	**Negligible**

TABLE A1-4 - RISK MATRIX DEFINITIONS	
Risk	**Definition**
Very High	There is a high probability that severe harm will arise to a designated receptor from an identified hazard OR there is evidence that severe harm to a designated receptor is currently happening. Urgent investigation/intervention and remediation are likely to be required.
High	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short term and are likely over the longer term.
Moderate	It is possible that harm could arise to a designated receptor from an identified hazard (source). However, there is a low likelihood that such harm would be severe, or if any harm were to occur it is more likely that the harm would be mild. Further lines of evidence are normally required to clarify the risk. Some remedial works may be required in the longer term.
Moderate/Low	It is possible that harm could arise to a receptor. However, a combination of likelihood and consequence results in a risk that is above low but is not of sufficient concern to be classified as moderate. It can be driven by cases where there is an acute risk which carries a severe consequence, but where the exposure is unlikely. Such harm would at worse normally be mild. The risk is unlikely to present a substantial liability. Some limited further investigation may be required to clarify the risk and any associated liability. If subsequent remediation works are necessary, they are likely to be limited in extent.
Low	It is possible that harm could arise to a receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Negligible	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is unlikely to be any worse than mild.

In consideration of the overall risk to the site from each identified contaminant linkage, GIA has typically considered risks above Low to require further investigation or intervention to mitigate risks to the identified receptor. Further site-specific detail is provided within our report for the identified contaminant linkages.

B1 RISK ASSESSMENT METHODOLOGY FOR HUMAN HEALTH

B1.1 Adoption of Generic Assessment Criteria (GAC)

In order to provide an assessment of the suitability of the chemical contamination status of the in-situ soils at the site for the proposed end-use, we have made reference to industry available Generic Assessment Criteria (GAC). Comparison of the laboratory soil test results will therefore be made against these GAC, which have been taken as initial Tier 1 screening values.

GIA has primarily adopted the use of the '*The LQM/CIEH S4Uls for Human Health Risk Assessment*' publication (to which we have a licensed publication; reference number S4UL3833). We note that these values represent a Minimal Risk Level (MRL) as opposed to a Low Level of Toxicological Concern (LLTC); as represented by the DEFRA published Category 4 Screening Levels (C4SLs). The S4UL publication notes that '*The LQM/CIEH S4Uls are intended for use in assessing the potential risks posed to human health by contaminants in soils and as transparently-derived and cautious 'trigger values' above which further assessment of the risks of remedial action may be needed*'.

In the absence of a suitable S4UL, as is notably the case for Lead, we have utilised the C4SL value for assessment purposes. It should be noted that the C4SL assessment of Lead already includes consideration of bioaccessibility (taken as being 60% for C4SL derivation purposes).

For other organic substances, we have referred to '*The EIC/AGS/CL:AIRE Soil Generic Assessment Criteria for Human Health Risk Assessment*', January 2010, ISBO 978-1-905046-20-1. GIA has utilised the toxicological input parameters used in the derivation of the original 2010 GACs and has derived in-house Tier 1 GAC adopting the exposure information utilised in the production of the more recent C4SL and S4UL publications.

Where a substance does not have a readily available UK screening value, we have reviewed the USEPA Regional Screening Levels; which, whilst not fully compatible with the UK context, provides an indicator as to the likely threshold levels below which human health risks are unlikely to result. Any additional Tier 1 GAC adopted will be detailed within our report.

GAC have only been adopted for determinands where they are present at laboratory reported concentrations above the Limit of Detection (LOD) of the instrumentation utilised for the analysis. The values adopted for our assessments are detailed within the main body of our report.

B1.2 Soil Organic Matter (SOM) Content

The Tier 1 GAC (detailed in B1.1) produced by LQM/CIEH have been derived for different Soil Organic Matter (SOM) contents, which can affect the behaviour of organic contaminants present within the soil.

For metals, a generic SOM value of 6% was utilised by LQM/CIEH, who note the following within the S4UL publication (Section 1.4.3): *'The LQM/CIEH S4Uls for metals are not sensitive to SOM and have been presented at 6% SOM, using suitable cautious inputs (e.g. Kd)*'.

For organic substances, GAC values were derived for SOM contents at 1%, 2.5% and 6% respectively, and we have adopted the most relevant GAC based on site-specific conditions (detailed within our report). Where deemed appropriate, GIA may also elect to model a site-specific GAC based on the SOM of the soil type being assessed (utilising the CLEA v1.071 model and the input parameters utilised by LQM/CIEH in the derivation of their S4ULs).

B1.3 Soil Type(s)

LQM/CIEH S4ULs were derived utilising a sandy loam soil type for all of the individual determinands. This represents a suitably conservative approach against which a Tier 1 human health risk assessment may be provided. For the majority of sites, GIA has utilised a sandy loam soil type as adopted within the S4UL GACs.

However, the CLEA v.1.071 model includes additional soil types which may be used for assessment purposes (including sandy clay loam, clay loam, silt loam and clay soils). Additionally, the modelling software allows for a site-specific soil type to be defined, subject to acquiring the necessary soil input parameters during the course of ground investigation works. Where considered appropriate, GIA may elect to utilise a different pre-defined soil type included within the CLEA model, or may derive bespoke GAC based on geotechnical laboratory soil test data. Justification for such an approach will be detailed within our report.

B1.4 Selection of End-Use

The S4UL and the EIC/AGS/CL:AIRE GACs, as well as the C4SL values (primarily relevant for Lead), were derived for different end-uses, reflecting the different sensitivities associated with likely exposure routes and receptor behaviours. GACs were derived for a total of six different modelling scenarios, including those applicable to a low-rise residential dwelling with private garden (a residential with plant uptake end-use), dwellings without private gardens or apartments (a residential without plant uptake end-use), Public Open Space within a residential estate (Public Open Space 1 end-use), recreational parkland (Public Open Space 2 end-use), allotments and a commercial premises.

These land uses cater for the majority of human health risk assessments required as part of the planning regime (i.e. as land proposed for redevelopment), and GIA has selected the most appropriate GAC reflecting the proposed end-use of the site. It is noted that GIA has derived in-house Tier 1 GAC values for the POS1 and POS2 end-uses for the EIC/AGS/CL:AIRE GACs.

B1.5 Assessment of Laboratory Soil Test Results

In order to initially understand whether a potential contaminant linkage exists for human receptors, laboratory soil test results have in the first instance been individually compared to the relevant GAC. Typically, this will be undertaken on a stratum specific basis reflective of the SOM and soil type applicable to the soils.

Where all of the determinands (present at concentrations above the laboratory LOD) are below the relevant GAC screening value, no specific contamination risk will have been identified to human health, and the soils may (subject to site-specific circumstances) be deemed to be chemically uncontaminated for the proposed end-use.

Where an exceedance to the GAC screening value is identified, further consideration of the result will be provided, potentially including an assessment of the likely provenance of the exceedance, consideration of the stratum type in question, and potentially consideration of the wider dataset to understand whether the contaminant is present at pervasive concentrations or is spatially (or vertically) localised. Reference to CL:AIRE, 2020 '*Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration*'. CL:AIRE, Buckinghamshire. ISBN 978-1-905046-35-5 will be provided, if and where appropriate, as part of our contamination assessment.

C1 RISK ASSESSMENT METHODOLOGY FOR GROUND GASES

C1.1 Applicable Standards

Ground gas guidance and the methodologies applicable to the risk assessment process are updated relatively frequently, with numerous documents discussing ground gas related risks available. GIA has utilised the following key guidance documents within our assessments, with reference to other documents as considered necessary (which will be detailed within our main report).

- British Standard BS8485:2015+A1:2019 '*Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings*'.
- British Standard BS8576:2013 '*Guidance on investigations for ground gas – Permanent gases and volatile organic compounds (VOCs)*'.
- CIRIA Report C665 '*Assessing risks posed by hazardous ground gases to buildings*' (2007).
- NHBC and RSK publication '*Guidance on evaluation of development proposals on sites where methane and carbon dioxide are present*', report edition No. 4 (March 2007).
- CL:AIRE research bulletin RB17 '*A pragmatic approach to ground gas risk assessment*' (November 2012).
- CL:AIRE technical bulletin TB17 '*Ground gas monitoring and 'Worst-Case' conditions*' (August 2018).
- CIRIA Report C682 '*The VOCs Handbook. Investigating, assessing and managing risks from inhalation of Volatile Organic Compounds (VOCs) at land affected by contamination*' (2009).

C1.2 Development of a Gas Screening Value

Current industry good practice guidance generally recommends that a risk-based approach to ground gas risk assessment is undertaken, which can comprise the derivation of a site-specific Gas Screening Value (GSV). The calculated GSV is then compared to the six defined Characteristic Situations detailed within Table 2 of BS8485:2015+A1:2019 and is used to inform the sites ground gas regime via selection of the most applicable Characteristic Situation (CS).

The GSV is calculated for both methane (CH_4) and carbon dioxide (CO_2), and is derived through the following process (after BS8485:2015+A1:2019):

- Calculation of borehole hazardous gas flow rates (Qhg values) for each borehole standpipe for each monitoring event;
- Assessment of the reliability of the measured gas flow rates and concentrations taking account of borehole construction and other factors (flooded response zones, atmospheric pumping effects, tidal effects etc.);
- Determination whether to utilise peak or steady-state gas flow rates for assessment purposes;
- Determination whether any temporal or spatial shortages in the data set are present and document how to overcome these data gaps;

- Consideration of the zoning potential of the site (this is only considered as a viable option where there is a clear and justifiable reason for considering the zonation of a site);
- Adoption of the most appropriate site-specific data for calculation of a site GSV taking all relevant information into account.

The guidance notes that '*The designation of GSV should be made after consideration of the available monitoring data…and all other relevant aspects of an adequate conceptual site model and with knowledge of the development's sub-structure and foundation arrangement.*'

C1.3 Worst Case GSV Check

Where the dataset is temporally or spatially limited, the peak or maximum steady state data can be combined from more than one monitoring standpipe location and different monitoring rounds. The need for the collection of additional data should be provided prior to adopting this approach, however in the absence of additional data then the guidance advocates the derivation of a GSV using worst-case conditions.

The requirements for a worst-case check are detailed within Section 6.3.7.4 '*Worst case check*' of BS8485:2015+A1:2019, which is undertaken using Equation C1 (see below), discounting any peak instantaneous flows and negative flows that have been judged to be unrepresentative of a possible worst-case; see main report for discussion over such considerations if applicable.

Equation C1: GSV = maximum recorded flow (l/hr) x (maximum gas concentration/100)

Where: GSV = Gas Screening Value (in l/hr)

As for each Qhg value, the calculated worst-case GSV (for both methane and carbon dioxide) is compared to the six Characteristic Situations detailed within the guidance, in order to inform the most applicable classification for the site.

Where the worst-case check indicates that a greater hazard potential could reasonably exist, then either this worst case GSV should be adopted or further monitoring undertaken to provide sufficient evidence that the worst-case should not be used.

C1.4 Consideration of Maximum Gas Concentrations

Once the site GSV has been selected (either utilising a representative Qhg value or worst-case GSV depending on site circumstances), it is also appropriate to consider the concentrations of ground gases revealed by the monitoring programme. This is primarily of note where the Qhg/GSV falls into a Characteristic Situation of CS1 due to low flow readings having been recorded, but where high ground gas concentrations have been revealed.

In accordance with Table 2 of BS8485:2015+A1:2019, where ground gas concentrations are in excess of 1% v/v for methane or 5% v/v for carbon dioxide, consideration should be given to increasing the Characteristic Situation from CS1 conditions (i.e. no ground gas precautions are required) to Characteristic Situation CS2 (i.e. gas precautions should be included within the design of the proposed development).

Engineering judgement should be used when proposing to increase the Characteristic Situation, and additional assessment can be provided to assist in understanding site-specific conditions. For example, this may include an assessment of the provenance of the ground gas recorded utilising Ternary Plots. Land Quality Management (LQM) Ltd has produced commercially available software for the derivation of such plots, and GIA has acquired a licence from LQM for their use.

C1.5 Other Ground Gases

The preceding sections (C1.2 to C1.4) primarily relate to an assessment of methane and carbon dioxide as potentially hazardous ground gases. However, other ground gases may be identified by the Conceptual Site Model (CSM) that require consideration as part of the ground gas risk assessment. Comments on the more common ground gases are provided below, together with the methodologies for assessment adopted by GIA.

Carbon Monoxide

With respect to risks to human health, BS8576:2013 provides thresholds for CO concentrations beyond which health effects may arise (included within Table D.1 '*Effects of carbon monoxide*'). Based on HSE guidance, the Long-Term Exposure Limit (LTEL) for an eight-hour period is listed as 30ppm (i.e. 0.003 % v/v), with the Short-Term Exposure Limit (STEL) measured over a fifteen-minute period listed as 200ppm (i.e. 0.02% v/v). These thresholds have been adopted for initial assessment purposes, as applicable to the site.

Hydrogen Sulphide

With respect to risks to human health, section D.2.4 '*Hydrogen Sulphide*' of BS8576:2013 provides a threshold range of 10ppm (0.001% v/v) to 20ppm (0.002% v/v) for eye irritation and identifies the HSE work-related exposure limits of 5ppm (0.0005% v/v) for the eight-hour LTEL and 10ppm for the fifteen-minute STEL. These thresholds have been adopted for initial assessment purposes, as applicable to the site.

Oxygen

Concentrations of oxygen in the ground can be used to inform detailed risk assessments for the potential microbial degradation of organic materials (i.e. can provide an indication of aerobic or anaerobic environments). However, for the purposes of a ground gas risk assessment, oxygen concentrations are primarily of concern where depleted oxygen conditions are present. This is principally a risk where construction personnel are required to gain entry into open excavations, where the displacement or depletion of oxygen can result in respiratory difficulties.

We have generally adopted a value of 17% v/v to indicate a potentially oxygen depleted environment, which is taken from The Coal Authority guidance document '*Guidance on managing the risk of hazardous gases when drilling or piling near coal*' version 2, April 2019.

In consideration of this threshold the guidance notes '*Once oxygen levels approach 17 % v/v breathing can become laboured and judgement impaired. Once oxygen concentrations approach 10% v/v there is a high probability of unconsciousness and death.*'

C1.6 Detailed Ground Gas Assessments

Where further refinement of the identified ground gas regime for a site is required (for example in marginal situations where it may be possible to re-classify the site as CS1 or alternatively where a significant risk has been identified and further exposure assessment is required), it may be necessary to undertake a more detailed assessment of the ground gas source(s) identified by the Conceptual Site Model (CSM).

Such works may include the sampling and analysis of extracted gas samples, installation of continuous ground gas monitoring devices, undertaking a forensic examination of the gas source soils (including ascertaining the potential degradable/organic content of the material), providing a Total Organic Content (TOC) profile of the ground stratigraphy or acquiring further lines of evidence via additional monitoring techniques (potentially including flux box testing or a surface emissions survey). Ground gas Detailed Quantitative Risk Assessment (DQRA) may then be undertaken, including modelling of surface emissions and the accumulation potential of ground gases beneath/within a building envelope.

C1.7 Ground Gas Precautions

Where the ground gas assessment has identified a potential risk to an identified receptor(s), it will be necessary to include suitable ground gas precautions within the design of the proposed development. The level of protection required will depend on the Characteristic Situation (CS) applicable to the site as well as the proposed building type (Type A to Type D as defined by Table 3 of BS8485:2015+A1:2019). These two parameters will enable a gas protection score for the site to be provided (see Table 4 of BS8485:2015+A1:2019), against which suitable ground gas precautions can be determined.

Once the minimum gas protection score for the site (or each building) has been established, a combination of two or more of the following three types of protection measures should be chosen by the Client to achieve the allocated point score:

- The structural barrier of the floor slab or basement slab and walls (where proposed);
- The ventilation measures proposed; and
- The provision of a suitable ground gas resistant membrane.

The chosen precautions should be documented within a site-specific ground gas verification plan, which will also detail the verification requirements necessary at the site.

C1.8 Vapour Risks

Where the CSM identifies a potential vapour risk to an identified receptor(s), detailed ground investigation works are required in order to establish the likely source, concentration(s) and chemical constituents of the volatile contaminants.

Initially, this may comprise an assessment of the soil concentrations by laboratory analysis, as well as the use of a hand-held Photo-Ionisation Detector (PID) to determine total concentrations of volatile compounds (TVOCs) within the soils. The PID may also be used during ground gas/vapour monitoring via the measurement of TVOCs within the well headspace of each monitoring well.

Where required, further assessment may include laboratory testing via sampling of the gases within the well headspaces, installation of monitoring instrumentation to measure in-situ volatile compound concentrations or Detailed Quantitative Risk Assessment (DQRA) works to model the exposure scenarios and to derive site-specific screening values/remedial targets.

APPENDIX 11

GIA Limitations

Limitations

- Ground Investigation Associates Limited (GIA) has prepared this report for the sole use of the Client, showing reasonable skill and care, for its intended purpose and in accordance with our Quotation, Terms and Conditions and instruction. This report may not be relied upon by any third party without the express agreement of the Client and GIA. No other warranty, expressed or implied, is made as to the professional advice included in this report.
- The scope of the investigation was designed based on the development proposed by the Client and taking into account the indicated site boundary. The scope is inappropriate for any other form of development or land not included in the site boundary as originally supplied.
- The report should be read in its entirety, including all associated drawings and appendices. GIA cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context.
- Although every reasonable effort has been made to gather relevant and available information, not all potential geotechnical or environmental constraints or liabilities associated with the site may have been revealed by the works undertaken.
- Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.
- GIA disclaim any responsibility to the Client and others in respect of any matters outside the scope of this report.
- 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 their own risk.
- The findings and opinions conveyed in any Desk Study section of the report (including review of any third party reports) are based on information obtained from the sources listed, which GIA understand are reliable. Reasonable skill, care and diligence has been applied in examining the information obtained. However, GIA accept no responsibility for inaccuracies in the data supplied or for opinions based on any such inaccurate data.
- A Phase I Desk Study collates available information to generate a preliminary Conceptual Site Model (pCSM). The actual geotechnical and environmental considerations can only be quantified by intrusive investigation works to confirm the accuracy of the pCSM.
- Where chemical analysis was carried out, this was targeted to identified key contaminants of potential concern based on our understanding of the available information. It should not be inferred that other chemical species are not present.
- Groundwater observations relate to conditions encountered at the time of investigation. It must be understood that groundwater levels may vary as a result of recent climatic conditions, tidal influence, seasonal variation and longer-term trends.
- Comments relating to ground conditions between, and below the base of, those encountered by GIA in exploratory holes are for guidance purposes only. No liability can be given for the accuracy of those comments.
- The works completed may be limited by the timeframe available and any restrictions associated with access, services, obstructions, and safe working practices.
- GIA is a geo-environmental consultancy. The scope of our works specifically excludes formal surveys relating to archaeological sites, asbestos-containing materials, invasive weeds, radioactive substances or Unexploded Ordnance.
- Drawings included in this report do not comprise an accurate base plan and are used to present the general relative locations of features on and in the immediate vicinity of the site. Such features should not be used for setting out and should be considered indicative only.
- This report has been prepared in accordance with our understanding of industry good practice guidance at the time of report production. Changes to good practice, guidance or legislation after the report date will necessitate a review and amendment of our report.
- Should any new information be provided to GIA relating to the environmental or geotechnical site conditions it will be necessary to review our report to assess whether it remains applicable.
- The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of GIA.