



GEOTECHNICAL
ENGINEERS

Delivering Innovative Solutions

Geo-environmental Assessment

Davidsons Developments

Lutterworth Road, Burbage

25th March 2022

Ref: PJSG21-58-DOC-01

Executive Summary

Environmental Risk Assessment Summary

Human Health Risk Assessment	Based on the contamination testing that has been carried out on the site, the risk assessment has indicated that the site poses a negligible risk to Human Health receptors. The natural topsoil and subsoils are considered to be suitable for retention / re-use on site if geo-technically suitable, subject to compliance with a Materials Management Plan (MMP).
Controlled Waters Risk Assessment	During the investigation, no significant evidence of contamination was identified below the site and no evidence of Made Ground was identified. The risk to groundwater / surface water associated with the site is considered very low to negligible and no further risk assessment considered to be warranted in that regard.
Ground Gas / Vapour Risk	Based on encountered ground conditions, gas protection measures are not considered to be required for the site. This recommendation should be confirmed with the relevant authorities prior to construction. No evidence vapours have been identified on site; no further assessment or mitigation is therefore required in that regard.
Ecological Risk	Potential impacts from contamination sources is considered negligible. However, the impact to ecological receptors from proposed construction activities should always be considered.

Geotechnical Assessment Summary

Foundations	Traditional strip / trenchfill foundations are generally considered appropriate for the proposed development bearing within firm to stiff cohesive and medium dense to dense granular deposits encountered beneath the site, subject to consideration of the loads imposed. An allowable design bearing pressure of 100kN/m² is recommended for trenchfill foundations (up to 1m wide), bearing uniformly in the firm cohesive deposits at a depth of 1m. An allowable design bearing pressure of 125kN/m² is recommended for trenchfill foundations (up to 1m wide), bearing uniformly in the firm to stiff cohesive deposits and/or the medium dense to dense granular deposits at a depth of 2m. At this stage, based on the illustrative site layout a significant number of plots are situated in close proximity to the site boundaries / on-site hedgerows and therefore foundation depths are likely to exceed 2.5m due to tree influence. In addition, unstable and /or low strength strata have been encountered within the southeast of the site. It is considered likely that plots coinciding with these areas will likely require a piled foundation solution.
Floor Slabs	At this stage it is anticipated that both ground bearing and suspended floor slabs may be suitable for the site, subject to developer preference and further assessment of proposed ground levels / tree influence.
Drainage	The cohesive geology encountered across the site would suggest that soakaway drainage is not considered feasible; an alternative drainage solution is therefore likely to be required. The advice of a Drainage Engineer should however be sought to confirm this preliminary assessment prior to construction.



Concrete	Soil results indicate Design Sulphate Class DS-1 and Aggressive Chemical Environment for Concrete Class AC-1 should be used for design purposes on all shallow foundations across the site.
Roads & Hardstanding	Based on the ground conditions identified and testing undertaken, it is considered that a preliminary CBR design values of 2 - 5% should be achieved for road construction design purposes for near surface deposits underlying the site.
Recommendations	
Delineation of any soft cohesive deposits and / or loose granular deposits identified within which coincide with proposed plots.	
Limited SI was undertaken within the northern field (WS04 – WS06) and within the southern central portion of the site. It is recommended that further SI is undertaken in these locations to obtain further ground data.	
Detailed foundation design.	
Further in-situ CBR testing is recommended at formation level once development proposals have been established.	
The drilling of deeper boreholes may be required to aid the design of piled foundations.	
Re-use of materials on-site should be controlled by a CL:AIRE approved Materials Management Plan (MMP).	



Document Issue Record

Document Number					
PJS Reference		PJSG21-58-DOC-01			
Status	Revision	Date of Issue	Author	Checked	Approved
Final	-	25/03/22	Nicholas Brown MSc AMIEnvSc	Vinny Hallifield (BSc Hons)	Martin Parker BSc (Hons) ICIQB
					

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Drawings

PJSG21-58-DR-001 –Site Location Plan
P17-1701_96-1 Rev. C – Illustrative Masterplan
PJSG21-58-DR-002 – Site Features Plan
PJSG21-58-DR-003-A – Exploratory Hole Location Plan

Appendices

Appendix A: Site Photographs
Appendix B: Exploratory Hole Logs
Appendix C: Chemical Testing Results
Appendix D: Geotechnical Testing Results
Appendix E: Gas and Groundwater Monitoring Results



1. Introduction

1.1 Instruction

In December 2021, PJS Geotechnical Engineers Limited (PJSG) were instructed by Davidsons Developments (the Client) to undertake a Geo-environmental Assessment at land off Lutterworth Road, Burbage, Leicestershire, LE10 2DW (the site).

A Site Location Plan (PJSG21-58-DR-001) is included within the Drawings Section of this report.

1.2 Proposed Development

Redevelopment proposals for the site are understood to comprise a residential development with gardens and areas of soft landscaping used as Public Open Space (POS).

An Illustrative Masterplan (P17-1701_96-1 Rev. C) has been provided by the client and is presented within the Drawings Section.

1.3 Objectives

The objectives of this assessment are detailed below:

Table 1-1 Objectives

Objectives
Confirm the suitability of the site for the proposed residential development, taking into account the ground conditions and contaminative status of the site.
Undertake a generic quantitative risk assessment to confirm the findings of the Initial Conceptual Site Model (ICSM).
Revision and update of the ICSM.
Identify suitable foundation depths and sub-structure design solutions.
Identify any potential geo-environmental issues that may cause abnormal development costs.
Make recommendations for any further investigation / remediation deemed necessary.

1.4 Previous Reports

The table below provides details of the relevant information sources which have been made available to PJSG for review in preparation of this report:

Table 1-2 Information Sources

Report Reference	Produced By	Report Name	Date
P9034	GRM	Phase 1 Site Appraisal (Desk Study)	August 2019



2. The Site

This section provides a brief overview of the site in its present condition, including the site's existing layout, general location and near surrounding land use.

A brief summary of the site's description is presented below in Table 2-1. The full details of the site are presented in the Phase 1 Desk Study Report referenced in Table 1-2.

A Site Features Plan (PJSG21-58-DR-002) is presented in the Drawings Section of this report. Photographs of the site are presented in Appendix A.

Table 2-1 Summary of Site Information

Specifics	Details
<i>Location</i>	Lutterworth Road, Burbage, Leicestershire, LE10 2DW
<i>National Grid Reference</i>	444698E, 291962N.
<i>Approximate Site Area</i>	8.6 Hectares (Ha).
<i>Topography</i>	The topography of the site generally slopes down from the northwest (~118m AOD) to the southeast corner (~106m AOD).
<i>Current Land Use</i>	Agricultural grass land comprising 7 No. separate fields. A number of fields comprise visible evidence of historic ridge and furrow farming techniques. It is understood that certain areas of the site are to be left undeveloped in order to preserve the ridge and furrow land. In addition, an area of land within the north has been designated as being 'species rich grassland' and 'of the highest conservation value.' It is therefore proposed that the grasses / topsoil within this area, is relocated to an adjacent field (not within this study site) prior to the development commencing.
<i>Existing Buildings / Retaining Structures</i>	None observed.
<i>Services / Utilities</i>	Overhead electric cables and a sewer are present in the north of the site, running parallel (west to east) with an existing hedgerow which divides the central and northern fields. An underground foul rising main is recorded in the southern portion of the site, running in a north easterly to south westerly direction. In addition, an unknown service has been identified during a geophysical survey, the service is approximately located in the centre of the site, running in north easterly to south westerly direction.
<i>Identified Potential Contamination Sources from Reconnaissance</i>	No significant sources were identified during on-site reconnaissance, as detailed within the Phase 1 Desk Study report.
<i>Vegetation / Invasive Plants</i>	Assessment of invasive plant species is beyond the scope of this report.
<i>Site Boundaries</i>	The site is bounded by mature trees and hedgerows on all sides.



Specifics	Details
<i>Surrounding Land Use</i>	North –Residential properties. East – Agricultural land. South – Transport Depot / M69. West – Lutterworth Road / Residential properties.
<i>Surface Water Features (Site & Vicinity)</i>	Several ditches are present on-site running alongside hedgerows, significant water was noted in the ditch located between the western and central field, flowing in a south easterly direction. The remaining ditches were noted to be dry.



3. Site Setting

3.1 Summary of Desk Study Information

The Desk Study report (referenced in Table 1-2) has been reviewed to provide a summary of the sites setting as detailed in Table 3-1 below.

It should be noted that the Desk Study undertaken by GRM comprised a larger site area and included the field directly to the east of this study site. Only pertinent information to the study site will be included in the below summary.

Table 3-1 Summary of Site Information

Historical Summary	
<i>Site</i>	The land use of the site has remained agricultural since the start of historical records to the present day. Several ponds have been identified on historical maps, however are no longer present on-site indicating that the ponds have been backfilled.
<i>Surrounding area</i>	The surrounding area of the site has also comprised predominantly agricultural land. Residential development has occurred directly to the north and west of the site. Features of note in close vicinity to the site include a derelict building adjacent to the northeast, a former hosiery factory located to the north west, a motorway cutting is located directly to the south of the site. A former sewage works was present ~250m to the east of the site. It is considered that all identified historical features are localised in extents and do not represent a significant risk to the site.
Geological Summary	
<i>Made Ground</i>	None recorded.
<i>Superficial Geology</i>	The majority of the site is shown to be underlain by Oadby Member deposits comprising Diamicton. Wolston sand and gravel deposits are recorded on the extreme western extents of the site. Bosworth Clay Member comprising clay and silt are recorded in the northeast and southeast of the site.
<i>Bedrock Geology</i>	Mercia Mudstone Group (Mudstone).
<i>Faults</i>	None recorded.
Hydrogeology	
<i>Aquifers</i>	Unproductive (Bosworth Clay) Secondary Undifferentiated (Oadby Member) Secondary A (Wolston Sand and Gravel) Secondary B (Mercia Mudstone Group)



<i>Source Protection Zones (SPZ)</i>	None recorded.
<i>Potable Abstractions</i>	None recorded.
<i>Groundwater Flow</i>	Groundwater is likely to flow towards the east / southeast taking into consideration the local topography.
Hydrology	
<i>Surface Water Features</i>	Several field drainage ditches are located on-site. A pond is recorded ~200m east of the site.
<i>Surface water flow</i>	Water flow was noted flowing in a south easterly direction within a drainage ditch recorded in the central field.
Mining & Ground Constraints	
<i>Mining</i>	The site is at negligible risk from coal mining / non-coal mining activities.
<i>Potential for Natural Ground Subsidence</i>	A moderate risk rating has been identified for compressible deposits likely to be associated with the Bosworth Clay Member. Compressibility and uneven settlement hazards may be present. Very low to negligible remaining ground stability hazards have been identified on-site.
<i>Radon</i>	The site is not within a radon affected area as less than 1% of properties are above the action level. Therefore, no radon protection measures are required within new dwellings.
<i>UXO</i>	The site has a low risk in regard to UXO. No further assessment required.
Environmental Records	
<i>Regulatory Records</i>	No significant environmental hazards, that are considered likely to pose a potential risk to the site have been identified.
<i>Landfills / waste sites</i>	No landfills or waste sites are recorded within 250m of site.



4. Preliminary Contamination Risk Assessment

In accordance with CLR11, a preliminary risk assessment (PRA) was completed for the site as detailed in the Phase 1 Desk Study report referenced in Table 1-2. The PRA is the first tier of risk assessment that develops the Initial Conceptual Site Model (ICSM) to establish whether there are any potentially unacceptable risks associated with the site.

The ICSM was developed based on the commonly adopted source-pathway-receptor (S-P-R) model as detailed within ICRM 2020. This was carried out in the context of the proposed development and potential contaminant linkages which may represent a risk to identified receptors. The ICSM contained within the Phase 1 Report has been reproduced and refined for the purpose of this assessment and is summarised in Table 4-3.

4.1 Potential Sources of Contamination

Sources (S); These are potential or known sources of contamination that may relate to a former land use or present site feature or process (e.g. fuel storage tanks). Sources relevant to the site identified within the Phase 1 Desk Study report are detailed in Table 4-1.

Table 4-1 Potential Sources of Contamination

Source Number (S)	Potential Sources	Inorganic Contaminants	Organic Contaminants
S1	On-Site: Potential for localised made ground from former backfilled ponds / vicinity of the site.	Naturally occurring metals, pH and possible asbestos fibres / fragments.	-
S2	On-Site: Potential for localised spills of fuels / oils from farm machinery using the land.	-	Poly-Aromatic Hydrocarbons (PAH), Total Petroleum Hydrocarbons (TPH), BTEX and Volatile Organic Compounds (VOCs).
S3	On-site: Agricultural Soils	Naturally occurring metals, pH and possible asbestos fibres / fragments.	-
S4	On-site: Natural Subsoils	Potentially elevated sulphates	-
S5	Off-site: ACMs falling onto site associated with disused building/s adjacent to the northeast boundary.	Asbestos fibres / fragments.	-

An off-site hosiery factory (to the northwest) and sewage treatment works (~250m east) were identified in the Phase 1 Desk Study. It is considered that these features will have no impact to site associated with the previous land uses and will therefore not be discussed further.



4.2 Potential Sources of Ground Gas & Vapours

It is considered that the following potential sources of ground gas / vapours may be present on site and in the surrounding area as detailed in Table 4-2.

Table 4-2 Potential Sources of Contamination

Source Number (S)	Location	Details	Source Generation Potential (CIRIA C665)
S1	On-site & off-site: Potential for localised made ground from former backfilled ponds / vicinity of the site.	Any Made Ground has the potential to generate elevated ground gas at the site. Particularly if any putrescible material is present.	Generally, very low but would be dependent on nature of any materials identified. Source is likely to be very localised
S3	On-site: Spills / leaks of fuels / oils from the various sources identified in Table 7-3.	The potential exists for localised VOCs to be present within any soils and / or groundwater below the site from localised spills of fuels / oils from farm machinery using the land.	Generally, very low and localised.
S6	On-site & off-site: Possible peat stratum in Wolston Sand and Gravel.	Peat has the potential to generate elevated ground gas.	Generally, very low and localised.

4.3 Potential Contaminant Linkages

In conclusion, it was considered that the site represents a low Environmental Risk for future residential redevelopment from an environmental perspective.

All plausible pathways (P) between the potential contaminant sources (S) and the receptors (R), i.e. S-P-R linkages, have been identified and are outlined in the ICSM presented in Table 4-3 overleaf using the information gathered within the Phase 1 Desk Study report.

Specific contaminants relevant to the identified source are listed in Table 4-1 and potential sources of ground gas are listed in Table 4-2 above.

Based on the identified sources of contamination and ground gas, the ICSM detailed in Table 4-3 (tabular form) provides details of the potential contaminant linkages that were identified during the PRA.

It was considered that the proposed development presented a **low** risk to Human Health and **very low** risk to Controlled Waters receptors. It is recommended that a ground investigation is undertaken to quantify the contaminant linkages and identify appropriate mitigation measures should they be required.

Table 4-3 ICSM and Potential Contaminant Linkages

Contaminant Linkage	Source (S)	Pathway (P)	Receptor (R)	Probability	Consequence	Current Risk	Investigation
Human Health							
1	On Site S1: Potential for localised made ground from former backfilled ponds / vicinity of the site. S2: Potential for localised spills of fuels / oils from farm machinery using the land. S3: Agricultural soils. Off Site S5: ACMs falling onto site associated with disused building/s adjacent to the northeast boundary.	P1: Ingestion of contaminated particulates. P2: Dermal contact. P3: Inhalation of contaminated dust / particles.	R1: Site end users.	Low	Medium	Low / moderate	Site investigation recommended to establish current levels of contamination and risk.
2			R2: Construction workers / maintenance workers.	Low	Medium	Low / Moderate	

Contaminant Linkage	Source (S)	Pathway (P)	Receptor (R)	Probability	Consequence	Current Risk	Investigation
3	On Site S1 & S3: as above Off Site S5: as above.	P3: Inhalation of contaminated dust / particles.	R3: Members of the public and residential properties adjacent to the site during construction	Unlikely	Medium	Low	Site investigation recommended to establish current levels of contamination and risk. Dust suppression to be adopted during construction.
4	On Site & off-Site S1 & S6: Ground gas arising from potential areas of localised Made Ground. S2: VOCs arising from sources listed above.	P3: Inhalation of vapours in indoor and outdoor air. P4: Migration of asphyxiant and explosive/ harmful gasses into confined spaces	R1 & R2 as above	Unlikely	Medium	Low	Site investigation recommended to establish current levels of contamination and risk.
Controlled Waters							
5	On Site	P5: Leaching of contamination into groundwater.	R4: Secondary (A) / (B) / Undifferentiated Aquifer.	Unlikely	Mild	Very Low	Site investigation recommended to establish current

Contaminant Linkage	Source (S)	Pathway (P)	Receptor (R)	Probability	Consequence	Current Risk	Investigation
6	S1 & S3: as above.	P6: Surface water on & off site via migration of contaminated groundwater and overland flow into surface water (run-off).	R5: On-site drainage ditch.	Unlikely	Mild	Very Low	levels of contamination and risk.
Property and Infrastructure							
7	On Site S4: Natural subsoils with potentially high sulphate concentrations.	P5: Leaching of sulphates, corrosive contaminants and / or acidic or alkaline leachate. P7: Direct contact with aggressive ground.	R6: Buried concrete & structures on-site and buried services.	Low	Mild	Low	Site investigation recommended to establish current levels of contamination.
Ecology							
8	On Site S1 - S3: as above	P8: Uptake of available phytotoxic contaminants via direct contact with contaminants.	R7: Ecological receptors Flora & Fauna on and off-site.	Low	Mild	Low	Site investigation recommended to establish current levels of contamination and risk.

5. Site Investigation

5.1 Summary of Site Works

The intrusive ground investigation works were undertaken on the 15th - 16th December 2021 and the 13th January 2022 by PJSG to establish the ground conditions beneath the site.

The locations of the exploratory holes were positioned taking into consideration the proposed development. No intrusive investigation works were carried out in the vicinity of identified underground or overhead utilities in the north, central and southern central areas of the site. Only boreholes were positioned within areas of the site where ridge and furrow / species rich grassland is present in order to minimise any disruption.

The ground investigation works were designed in general accordance with BS10175:2011+A2:2017 'Investigation of Potentially Contaminated Sites'. Further details of the ground investigation work undertaken, including the rationale for the location of the exploratory holes are detailed below in Table 5-1.

An Exploratory Hole Location Plan (PJSG21-58-DR-003-A) is provided within the Drawings Section of this report.

Table 5-1 Summary of Site Investigation Works

Method / Activity	No.	Hole Reference	Depth Range (m)	Testing	Gas & Groundwater Ancillaries	Rationale
Investigation Method						
Window Sample Borehole (WS)	20	WS01 to WS20.	3.00 – 5.00	*SPT's	8	To determine ground conditions.
Machine Excavated Trial Pits (TP)	21	TP01 to TP21.	2.30 – 3.40	Hand Shear Vanes (HSVs)	-	To determine ground conditions.
Gas & Groundwater Monitoring						
Gas data meter, flow meter and groundwater dip meter	6 to date.	WS01, WS03, WS07, WS08, WS10, WS13, WS15 and WS16.	-	Ground gas & Groundwater monitoring	-	To further determine the ground gas regime in accordance with CIRIA C665.

*SPTs undertaken in accordance with the guidance set out within BS EN 22476-3 2005 +A1:2011;

The exploratory logs are presented within Appendix B and the results of the SPT / HSV tests are shown on the individual exploratory hole logs.

The SPT hammer calibration certificate for the WS drilling rigs is also included within Appendix B.

5.2 Laboratory Testing and Sampling

Representative soil samples of the various strata types present were collected during the site investigation works by a suitably qualified engineer. Samples were recovered using a stainless-steel trowel and disposable gloves.



Samples were stored in cooler boxes prior to being transported to an MCERTS accredited laboratory. A selection of these samples was tested for the presence of contaminants and for classification purposes. Chemical testing was undertaken by i2 Analytical Ltd and Chemtech Environmental, whilst geotechnical testing was undertaken by Exploration & Testing Associates Ltd.

A summary of the laboratory testing carried out is presented below.

Table 5-2 Summary of Laboratory Testing

Quantity	Analysis
Chemical Testing - Soils	
12	PJS Contamination Suite comprising: Moisture content, pH, Organic matter, Speciated USEPA 16 PAHs, Metals: As, Cd, Cr III & VI, Cu, Pb, Hg, Ni, Se, Zn, Water soluble sulphate (SO ₄).
9	Asbestos Identification (ID).
6	BRE Suite B (Greenfield but possibly pyritic)
Geotechnical Testing	
11	Moisture Content
11	Liquid and Plastic Limits
1	Particle Size Distribution (grading analysis)

Geotechnical laboratory testing was generally carried out in accordance with the relevant part of BS1377: 1990, *Methods of Test for Soils for Civil Engineering Purposes*, or, where superseded, by the relevant part of BS EN ISO 17892:2014+ *Geotechnical investigation and testing – Laboratory Testing of Soil*.

The laboratory results are included within Appendix C and D of this report.



6. Ground Conditions

6.1 Summary of Ground Conditions

The geology encountered during the intrusive investigation was generally consistent with geological records. A summary of the general strata encountered across the site is provided in the Table 6-1 below, with more detailed descriptions given on the exploratory hole logs presented within Appendix B.

6.2 Summary of Geological Descriptions

The geology encountered below the site is described below.

Table 6-1 Geological Descriptions

Topsoil	Topsoil	Encountered at all locations and generally recovered as a sandy clayey TOPSOIL. The depth of topsoil encountered across the site ranges between 0.25 to 0.40m, with an average thickness of 0.35m.
Superficial Geology	Glacial Cohesive Deposits	Encountered within all exploratory hole locations generally comprising an upper horizon of firm brown sandy gravelly CLAY overlying a lower horizon of firm to stiff grey gravelly CLAY. Gravels comprised fine to coarse, angular to sub-rounded quartzite, siltstone, mudstone and chalk. Stiff grey clayey SILT was encountered within WS14 at a depth of 3.00 to 5.00m, albeit a localised soft pocket was noted between 4.50 – 4.75m.
	Glacial Granular Deposits	Encountered at 11 No. exploratory hole locations (TP05, TP15, WS01, WS02, WS04 - WS06, WS15, WS16, WS18 and WS20) generally comprising wet clayey gravelly SAND. Yellowish brown very wet clayey very sandy GRAVEL was encountered within TP19 (southeast) at depth of 1.10m, the excavation was aborted at 2.40m due to instability within this stratum.
Bedrock Geology	Mercia Mudstone Group	Not encountered at any exploratory hole locations.

6.3 Summary of Field Observations

The following field observations were made during the intrusive investigation works.

Table 6-2 Field Observations

	Locations Encountered	Observation	Depth Range (m)
Groundwater	TP01	Slight groundwater ingress	1.60
	TP02	Slight groundwater ingress	1.20
	TP05	Wet strata	1.40
	TP15	Land drain struck	1.70
	TP19	Land drain struck	0.80
	TP20	Groundwater ingress	2.20 – 2.40
	WS01	Groundwater at base	4.00



	Locations Encountered	Observation	Depth Range (m)
	WS02	Groundwater	3.00
	WS05	Groundwater	3.00
	WS07	Groundwater	2.00
	WS10	Groundwater	2.00
	WS11	Groundwater at base	5.00
	WS14	Groundwater	2.00
	WS15	Groundwater	4.00
	WS16	Groundwater	1.00
	WS19	Groundwater	1.00
	WS20	Groundwater	2.00
Instability / Trench Collapse	TP05	Minor collapse	1.40 – 2.10
	TP15	Unstable	1.70 – 2.30
	TP19	Unstable	1.10
	TP20	Major collapse	1.20
	WS01	Borehole collapse	3.40 – 4.00
	WS16	Borehole collapse	3.00 – 5.00
Soft / Loose Strata	TP11	Pockets of soft clay	0.30 - 1.00
	TP18	Pockets of soft clay	0.70 – 1.00
	WS02	Soft clay	1.00 – 2.00
	WS04	Loose sand	1.00 – 1.50
	WS05	Soft clay / Loose sand	1.00 – 1.60
	WS06	Loose sand	1.10 – 1.80
	WS08	Soft clay	0.25 – 1.00
	WS11	Soft clay	0.40 – 0.70
	WS14	Soft silt	4.50 – 4.75
	WS17	Soft clay	
	WS18	Loose sand	1.00 – 2.00
	WS20	Soft clay	1.00 – 1.40
Running sands	TP20	Running sands	1.20
Contamination	Not encountered	-	-

6.4 Summary of SPT Testing within Boreholes

A summary of the uncorrected SPT N Values recorded in the boreholes advanced across the site is summarised below in Table 6-4.

Table 6-3 SPT Summary in relation to Ground Conditions

Borehole Ref:	SPT 'N' Value with Depth					
	1m	2m	3m	3.8m	4m	5m
WS01	19	25	24	-	23	-
WS02	6	14	24	50	-	-
WS03	15	16	50	-	-	-
WS04	7	16	25	-	27	-
WS05	4	19	13	-	31	35
WS06	8	14	21	-	27	-
WS07	11	14	19	-	11	19
WS08	9	13	16	-	30	31

Borehole Ref:	SPT 'N' Value with Depth					
	1m	2m	3m	3.8m	4m	5m
WS09	11	16	28	-	41	34
WS10	11	16	20	-	20	-
WS11	12	18	22	-	19	27
WS12	11	13	20	-	32	28
WS13	8	10	17	-	29	-
WS14	8	12	14	-	17	19
WS15	9	14	14	-	12	10
WS16	4	19	14	-	12	7
WS17	4	20	19	-	29	-
WS18	7	21	31	-	29	23
WS19	9	13	18	-	13	23
WS20	4	16	50	-	-	-

Natural cohesive deposits – Natural Granular Deposits

Several low N value results in both granular and cohesive stratum have been recorded during the PJS investigation. The implication of the low N Values encountered is discussed further in Section 7.0. The recorded SPT N values are detailed on the exploratory hole logs presented within Appendix B.

6.5 Gas & Groundwater Monitoring

To characterise the ground gas regime for the site, gas and groundwater monitoring has been carried out on 6 No. monitoring visits to date between 23rd December 2021 and 23rd March 2022 at atmospheric pressures ranging between 983mb to 1025mb

The concentration (initial and steady state) of methane (CH₄), carbon dioxide (CO₂), oxygen (O₂) by percentage volume and gas flow rates within each borehole were recorded. Weather conditions and atmospheric pressures before, during and after monitoring were also recorded. A summary of the ground gas monitoring results obtained to date are displayed in the table below.

Table 6-4 Ground Gas Monitoring Summary

Ground Gas Monitoring Summary	Minimum	Maximum
Methane (CH ₄) %	< 0.1	0.3
Carbon dioxide (CO ₂) %	< 0.1	2.6
Oxygen (O) ₂ %	14.6	21.2
Carbon monoxide (CO) PPM	0	16
Hydrogen sulphide (H ₂ S) PPM	0	0
Atmospheric Pressure (mb)	991	1025
Flow Rates (m/s)	*<0.1	2.5

**The limit of detection has been used for negative flows rates.*

A summary of the groundwater monitoring results obtained to date are displayed in the table below.

Table 6-5 Groundwater Monitoring Summary

Borehole Ref.	Minimum Depth bgl. (m)	Maximum Depth bgl. (m)	Response Zone Flooded on Arrival (Y/N)	Number of Occasions Flooded
WS01	1.33	2.00	Y	2 of 6
WS03	0.85	1.17	Y	3 of 6
WS07	0.60	0.63	Y	6 of 6
WS08	0.70	0.74	Y	6 of 6
WS10	0.80	0.83	Y	5 of 6
WS13	0.98	1.04	Y	2 of 6
WS15	1.37	1.53	N	-
WS16	0.46	0.49	Y	6 of 6

To facilitate ground gas monitoring, the initial groundwater depth was recorded in boreholes then each of these boreholes was bailed dry and was left to stabilise for a period. Gas monitoring was then undertaken.

The gas and groundwater monitoring results are contained within Appendix E of this report.



7. Geotechnical Assessment

7.1 Introduction

Redevelopment proposals for the site are understood to comprise the construction of residential buildings with areas of hardstand and soft landscaping.

At this stage, an illustrative masterplan has been provided and is presented in the Drawings section of this report.

7.2 Material Properties

To assist with foundation design, in-situ testing and geotechnical classification testing has been undertaken on a selection of the soil samples recovered from site. The geotechnical properties of the soil types encountered across the site as summarised in the sections below.

Geo-technical analysis of the samples was carried out by Exploration & Testing Associates Ltd. Results are contained within the Appendix D.

7.3 Particle Size Distribution (PSD) Analysis

1 No. PSD analyses were undertaken on samples recovered from site to aid in the classification of soils. Classification was undertaken in accordance with BS1377: 1990 Part 2: Clause 9.2 and the results of the tests are summarised below:

Table 7-1 Summary of PSD Analysis

Sample Location	Depth (m)	Lab Soil Description	Percentage Passing (%)			
			Very Coarse Soils (>63mm)	Gravel (63mm – 2mm)	Sand (2mm - 0.063mm)	Fines (<0.063mm)
TP19	1.40	Brown slightly sandy CLAY	0	2	20	78

The results of the PSD test confirms that the strata sampled comprises predominately cohesive material and therefore soils at this location should be treated as cohesive rather than granular.

7.4 Plasticity Index & Volume Change Potential

A total of 12 No. Plasticity Index (PI) tests were undertaken on soil samples in accordance with BS1377-2: 1990 Clause 3.2, to determine the Modified Volume Change Potential (VCP) in accordance with NHBC Standards (Chapter 4.2).

Results of the PI tests and the related VCP of the samples is summarised below.



Table 7-2 Summary of Plasticity Testing

Sample Location	Depth (m)	Strata	Moisture Content (%)	Plasticity Index (%)	Percentage Passing 425µm Sieve (%)	Modified Plasticity Index (%)	VCP
TP03 – D1	2.40	CLAY	24.00	24.00	98.00	23.52	Medium
TP05 – D1	1.00	CLAY	26.00	24.00	98.00	23.52	Medium
TP05 – B1	2.00	Very clayey SAND	18.00	19.00	97.00	18.43	Low
TP11 – D1	2.40	CLAY	17.00	20.00	93.00	18.60	Low
TP15 – D1	1.50	CLAY	22.00	9.00	98.00	8.82	Non-shrinkable
TP15 – B1	2.00	Clayey SAND	13.00	-			
TP19 – B1	1.40	CLAY	24.00	17.00	97.00	16.49	Low
WS01 – D1	2.00	CLAY	14.00	15.00	88.00	13.20	Low
WS13 – D1	1.00	CLAY	17.00	16.00	97.00	16.49	Low
WS14 – D1	1.80	CLAY	26.00	23.00	100.00	23.00	Medium
WS14 – D2	3.00	SILT	24.00	10.00	98.00	9.80	Non-shrinkable

Geotechnical testing has determined the cohesive deposits beneath the site to range from non-shrinkable to medium VCP as indicated in the above table.

Samples of granular material were obtained and tested for plasticity at a depth of 1.40m and 2.00m from TP05 and TP19 respectively, in order to confirm if the strata were non-shrinkable. The test result for these samples indicate modified VCP results of 18.43% and 16.49% and therefore the materials should be classified as low VCP.

Based on the results it is considered that a medium VCP should be assumed for foundation design purposes.

Where founding in medium VCP deposits detailed foundation design will be required to determine the required founding level in accordance with NHBC Guidelines Chapter 4.2 – Building Near Trees. Heave precautions will also be required on the inside face of foundation trenches.

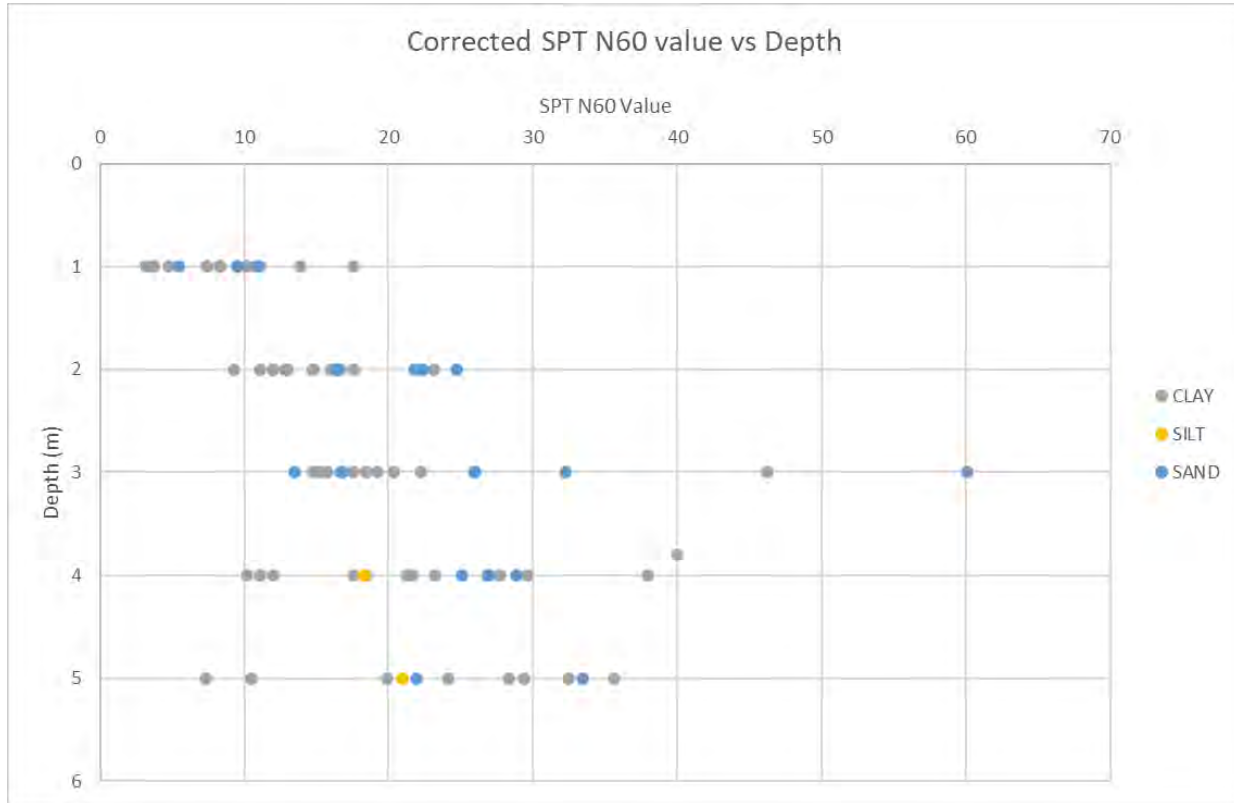
In accordance with NHBC standards, foundation depths should be a minimum of 0.90m below existing or reduced levels (where foundations are located outside the zone of influence of trees) within cohesive deposits.

7.5 In-situ Standard Penetration Testing

Standard Penetration Tests were undertaken at regular intervals during drilling of the window sample boreholes in accordance with the methodology outlined in British Standard BS EN 22476-3 2005.

A plot of corrected SPT N values recorded with depth below the site during the investigation is presented below in Figure 1. A copy of the SPT calibration certificate for the window sample drilling rig is presented within Appendix B.

Figure 1 - Corrected SPT N60 Value with depth



Results of the corrected SPT N60 testing would indicate that cohesive deposits generally comprise firm to stiff clays which increase in strength with depth. The N60 values for the granular strata indicate that materials generally comprise medium dense sands.

Loose granular deposits have been identified at a depth of 1m within WS04, WS05 and WS06 located in the north and within WS18 located in the west of the site.

Very soft to soft cohesive deposits have been identified at a depth of 1m in WS02 located in the northern field and within WS16, WS17 and WS20 all located in the south / southeast of the site. Soft cohesive deposits were also noted with WS16 at a depth of 5m, which coincided with poor sample recovery.

7.6 Undrained Shear Strength

The undrained shear strength of the materials has been estimated from the SPT N Values by empirical correlation as described in CIRIA Report C143 (after Stroud and Butler, 1975):

Where c_u is the undrained shear strength, N is the SPT N value and f_1 is an empirical correlation factor based on the soil plasticity index. The soil plasticity data obtained from soil samples recovered below the site during the investigation has been used. The samples of granular strata are not considered to be representative of the cohesive

deposits beneath the site and therefore have been removed from the data set below in order to gain the F_1 value. Based on the plasticity index testing carried out, the values in Table 7-3 have been assumed for the purpose of calculation.

Table 7-3 Calculated F_1 Values

Strata	Average I_p	F_1 Value
Cohesive	20	5.4

Calculated using corrected N60 value range of 3 – 46 the estimated undrained shear strength of the cohesive strata is between 17 kN/m² and 250 kN/m².

Figure 2 – Calculated Shear Strength with depth

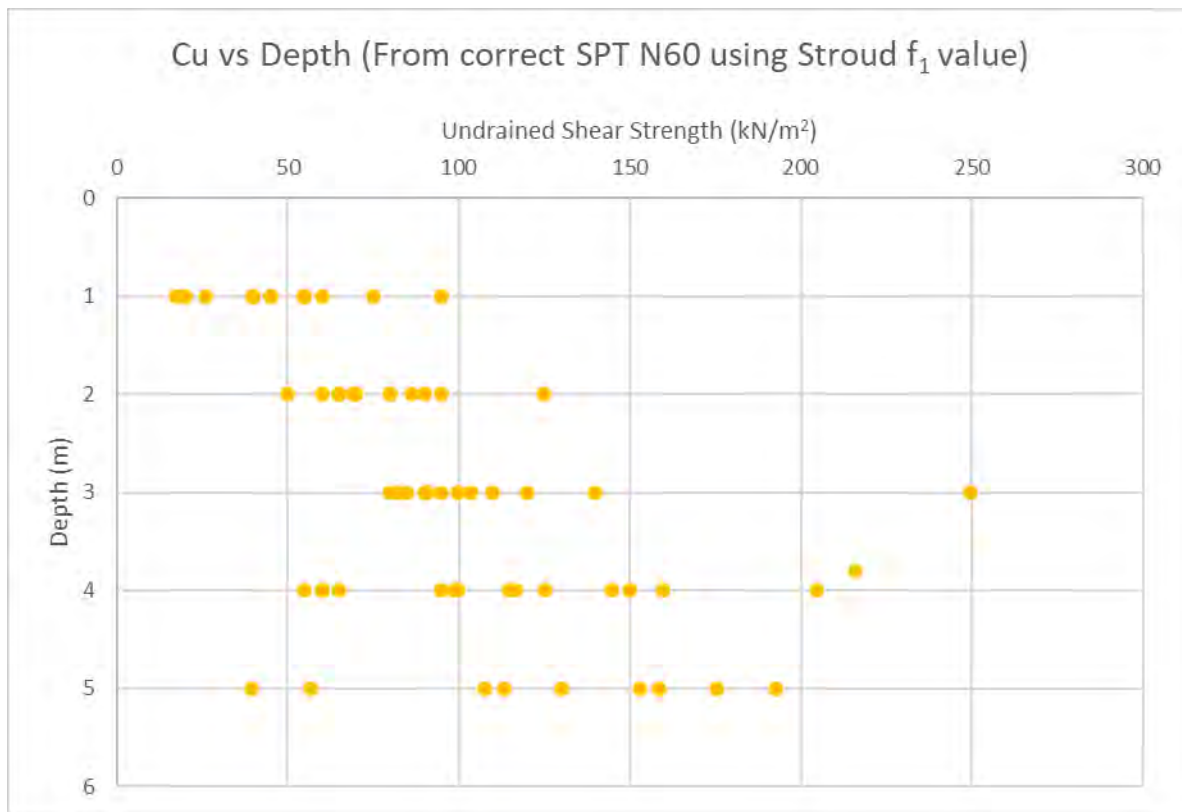


Figure 2 presents a plot of the estimated undrained shear strength with depth beneath the site based on the soil plasticity testing as described above. The results show a clear trend of increasing shear strength with depth.



In-situ Hand Shear Vane (HSV) tests were also carried out in the near surface cohesive deposits between depths of 0.90m and 2.40m bgl which ranged between 50 kPa and 105 kPa (site average of ~65kPa at a depth of 1m) which indicates the cohesive deposits to range between medium to high strength.

Figure 3 - HSV with depth

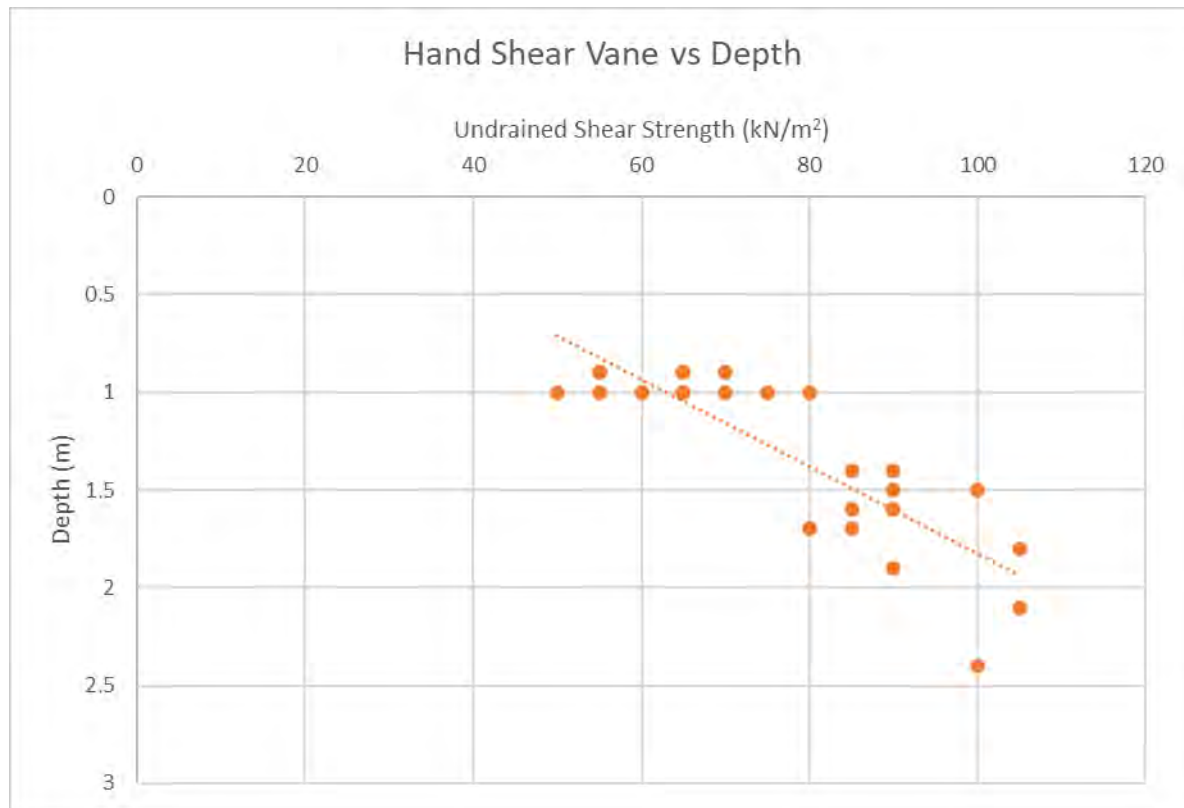


Figure 3 presents a plot of the in-situ HSV test results in relation to the recorded undrained shear strength with depth of cohesive materials beneath the site. The results show a clear trend of increasing shear strength with depth.

7.7 Material Properties Summary

A summary of the material properties / strength characteristics for the cohesive deposits underlying the site is presented below in Table 7-4.

Table 7-4 Material Properties Summary

Strata	Depth (m)	Average N60 Value	Average Undrained Shear Strength (kPa) from N60.	Recommended Allowable Bearing Pressure (kPa)
Cohesive	1.00	9	46	100
Cohesive	2.00 +	14	76	125
Granular	2.00	20	-	125



7.8 Foundation Assessment.

The following section presents recommendations for foundations for the proposed development taking into consideration the ground conditions encountered and the material properties.

Traditional Foundations

Traditional strip / trenchfill foundations are generally considered appropriate for the proposed development bearing within firm to stiff cohesive and medium dense to dense granular deposits encountered beneath the site, subject to consideration of the loads imposed.

An allowable design bearing pressure of 100kN/m² is recommended for trenchfill foundations (up to 1m wide), bearing uniformly in the firm cohesive deposits at a depth of 1m. An allowable design bearing pressure of 125kN/m² is recommended for trenchfill foundations (up to 1m wide), bearing uniformly in the firm to stiff cohesive deposits and/or the medium dense to dense granular deposits at a depth of 2m. These values include a factor of safety of 3.0 against general shear failure and should result in total settlements of not more than 25mm for foundations up to 1m wide, keeping differential settlements within acceptable limits. Foundations should extend through any soft cohesive / loose granular deposits.

Foundations should be placed at a minimum depth of 0.9m, based on medium VCP clays. Where plots are underlain by cohesive strata and within the influence of existing trees / hedges, foundations will require deepening in accordance with the NHBC guidelines. Foundations may also need to be stepped in the base of the foundations; any steps should be in accordance with the NHBC guidelines.

Where strip / trenchfill foundations are adopted and plots are affected by tree influence and within cohesive deposits, heave precautions to include for the provision of a 250mm void beneath beam and block floor slabs will be required. Further heave precautions include a requirement for a 25mm void on the inside face of all external foundations should foundation depths exceed 1.5m due to tree influence.

Several exploratory holes encountered unsuitable ground conditions at shallow depth, however are still deemed to be potentially suitable for traditional foundations (subject to proposed levels). The potential options at these locations are displayed in the below table:

Table 7-5 Unsuitable Ground Conditions

Exploratory Hole Ref.	Constraint	Solution/s
WS02	Soft clay @ 1m	Localised deepening of foundations to ~2m.
WS04	Loose sand @ 1m	Localised deepening of foundations to ~2m.
WS05	Loose sand @ 1m	Localised deepening of foundations to ~2m.
WS06	Loose sand @ 1m	Localised deepening of foundations to ~2m.
TP15 / WS18	Loose / unstable sands	Further plot specific investigation. Engineer supervision and plots cast on a dig and pour basis to limit trench instability issues.

Alternative foundation solutions may be required at the above locations should the unsuitable ground conditions be more widespread and / or at depths exceeding 2m.



Where any contrasting ground / localised soft spots are encountered at founding level, steel mesh reinforcement (B785 or similar) may be required in the base of foundations to span the different strata types / low strength material and counter any potential differential settlement. Should steel be required, RC35 concrete should be adopted.

Care should be taken to avoid softening of the base of the foundation excavation during construction. Where necessary, a 100mm blinding of concrete should be constructed to protect the foundation level during bad weather. The excavation should not be left open for any extended period.

Foundation widths should be designed as part of detailed design by a Structural Engineer, appropriate to the loads being imposed, however 0.60m wide foundations are likely to be appropriate for external walls and 0.75m wide for party walls and gable ends.

Foundations will need to be deepened through any made ground, it should be noted that no made ground was encountered within the site investigation.

Topsoil should be removed from beneath plot footprints.

It is recommended that foundation trenches should be inspected by an Engineer prior to pouring concrete to confirm that foundations are placed uniformly within firm to stiff cohesive clay deposits or medium dense granular deposits where appropriate. It is recommended that confirmation of the shear strength of the in-situ cohesive soils in the base of foundation excavations (using a HSV or similar) is also carried out to ensure that the allowable bearing pressure is achieved. A minimum shear strength of 50kPa should be determined before casting foundations.

It is recommended that detailed foundation design is undertaken prior to construction to confirm compliance with appropriate guidance and the most cost-effective foundation solution. A tree survey shall be required in order to facilitate foundation design.

Alternative Foundation Options

Unstable granular deposits and / or low strength cohesive strata have been encountered within the southeast of the site, within TP19, TP20, WS16, WS17 and WS20 at depths ranging from 1.00 to 5.00m. It is considered that shallow soils in these areas of the site may not be suitable for traditional foundations and may require alternative foundation solutions.

Based on the proposed site layout issued to PJS, exploratory holes TP20, WS16 and WS17 are all located within areas of the site where no plots are not proposed.

Where unstable and /or low strength strata has been encountered within the southeast of the site (TP19 and WS20), site levels are due to be raised significantly or foundations depths exceed 2.5m due to tree influence then alternative foundations (such as piled or ground improvement) may be required.

The choice of any alternative foundation solution/s will be based on a number of factors including the developer's preference along with economic, social and environmental factors. At this stage the following options are considered to be most appropriate:

Piled Foundations

At this stage, based on the illustrative site layout a significant number of plots are situated in close proximity to the site boundaries / on-site hedgerows and therefore foundation depths are likely to exceed 2.5m due to tree influence.



In addition, unstable and /or low strength strata have been encountered within the southeast of the site. It is considered likely that plots coinciding with these areas will likely require a piled foundation solution.

Any piled plots will require reinforced ground beams, which can be either pre-cast or cast in-situ depending on developer preference, and should be designed by a specialist contractor or Structural Engineer.

Where plots to be piled are within the influence of existing or removed trees heave precautions shall be required comprising compressible material on the inside face (25mm) and underside of ground-beams (100mm). The piling contractor should consider the risk of heave on the actual pile shaft or column.

An allowance should be made for a working platform to support a piling rig.

Based on the available ground information, concrete driven piles are likely to be suitable. Steel piles may be required if driving resistance is high or a reduction in ground vibration is required. Bored piles may be required if ground conditions are not conducive to driven piles or if detailed design demonstrates bored piles could be founded at shallower depths. A specialist piling contractor should be consulted for site specific pile type and design.

Further site investigation consisting of deeper boreholes may be required to determine pile depths should this foundation option be desired. It is recommended that advice is obtained from specialist piling contractors to ascertain the most economical solution for the ground conditions encountered.

Ground Improvement

Vibro ground improvement may be feasible as a foundation solution subject to a full assessment and detailed foundation design. However, given the cohesive materials and numerous mature trees and / or hedgerows are present on-site, any vibro treated foundations will require deepening in accordance with the NHBC guidelines. Based on this it is considered unlikely that vibro ground improvement will prove to be an economical foundation solution.

7.9 Floor Slab Construction

At this stage it is anticipated that both ground bearing and suspended floor slabs may be suitable for the site, subject to developer preference and further assessment of proposed ground levels / tree influence.

For plots where depths of fill exceed 600mm below the floor slab or are founded within cohesive deposits and tree influence exceeds 1.5m, ground bearing slabs will not be suitable and suspended floor slabs should be adopted.

The final specification of ground floor slabs will be subject to detailed design, taking into account existing and proposed levels and the impact of trees/vegetation.

7.10 Excavations

Excavations using conventional plant are expected to be suitable in the natural strata across the site. Mechanical breaking equipment is unlikely be required given the type of material encountered below the site and observations made during the investigation works.

Instability of trenches was noted within several excavations predominately within the southeast of the site. If possible, excavations should avoid extending into the water table where possible. Support of excavations and a suitable de-watering plan should be present during construction works.

Excavations that remain open for long periods, particularly during inclement weather are expected to be prone to instability. Where personnel entry is required for inspection, excavations should be sufficiently enlarged and an assessment of safe temporary angles should be assessed; alternatively, temporary shoring should be provided.



No excavations should be entered until a full risk assessment is completed to assess the stability requirements and safety issues.

7.11 Earthworks

In the event that any significant site re-profiling is required, it is recommended that a site-specific Earthworks Specification is produced to control the re-use and placement of materials. Additional geotechnical testing should be undertaken prior to and during the earthworks exercise in order to classify materials appropriately. The Earthworks Specification should consider the chosen foundation and floor slab design.

A Materials Management Plan (MMP) should be created for the site in the event that site-won materials are proposed to be re-used during the development, in order to ensure compliance with the current waste legislation.

7.12 Slope Stability

The previous Desk Study undertaken made the following recommendation, '*Consideration should be given to the stability of the slope down to the M69 motorway that forms part of the site's southern boundary. At this stage the risk to the slope is considered very low to low as there is at least a 2m gap between the site boundary and the crest of the approximately 2m high slope. Any works which may influence the M69 slope will probably require an Approval in Principle (AIP).*'

It is considered that the following actions may cause instability and potential failure of the slope:

- any significant re-grading of the site in close proximity to the southern boundary,
- removal of trees / vegetation from the existing slope,
- interference with drainage around the existing slope,
- surcharging of the crest of the existing slope.

During the site walkover, a visual inspection was undertaken by PJS from the crest of the slope, it should be appreciated that access to the slope and visibility of the slope from the crest was restricted by the presence of dense vegetation.

The slope forms part of a cutting which runs along the southern boundary of the site, associated with the M69 motorway; and comprises a cut-slope with the existing northbound carriageway and hard shoulder of the motorway at its base. The surface of the slope is heavily vegetated with a combination of mature and semimature trees, shrubs and ground cover.

The slope itself is not used, nor accessible, by motorway users or site users; and is separated from both the motorway and the current study site by a series of fences and barriers.

Based on historical mapping, the M69 appears to have been constructed in the 1970's and therefore the cutting slope has been in-situ for ~40 years without any apparent slope failures noted in this area.

Visible distress to the existing trees / vegetation, or other evidence of significant ground movement at the crest of the slope was not observed.



The proposed development comprises the construction of traditional low-rise residential dwellings and associated access roads. The preliminary site layout indicates that the nearest residential property / road infrastructure is ~75m to the north of the slope. A detention basin is currently proposed within the southeast field.

It is understood that there are currently no plans to make any alterations to the slope profile and that the current vegetation is to remain in-situ, albeit it is likely that Highways England will undertake maintenance works from time to time.

TP21 was excavated within the PJS investigation and was located within the footprint of the proposed basin. Ground conditions comprised firm brown sandy gravelly clay to a depth of 1.60m overlying stiff grey / brown gravelly clay to a depth of 2.60m. No instability of the trial pit sides or groundwater was encountered during the excavation.

Based on current information available and the distance to proposed residential properties it is considered that the proposed development will have a negligible impact on the slope adjacent to the southern site boundary. However, any future design must carefully plan any proposed drainage and SUDS features to ensure that any such features are suitably designed and located to avoid discharge into the slope area, either over the surface or via any granular subsurface beds (unlikely based on ground conditions in TP21). Any proposed construction works near to the crest of the slope should be carefully planned as part of detailed design and supervised to ensure that the stability of the slope is not compromised in the short-term by the use of plant and equipment.

7.13 Obstructions

No significant obstructions are anticipated based on observations made during the ground investigation works.

7.14 Drainage

The cohesive geology encountered across the majority of the site would suggest that soakaway drainage is not considered feasible; an alternative drainage solution is therefore likely to be required. The advice of a Drainage Engineer should however be sought to confirm this preliminary assessment prior to construction.

7.15 Roads & Hardstanding

Ground conditions suggest that a minimum CBR value of 2 - 5% within the natural ground should be appropriate for road design across the site.

Further in-situ CBR testing is recommended at formation level once development proposals have been established to confirm CBR values and required road construction.

7.16 Concrete Classification

The laboratory results have been assessed against the BRE Special Digest 1 2005: 3rd Edition Aggressive Chemical Environment for Concrete (ACEC) Site classification. The Site has been designated as Greenfield ground with mobile groundwater.

Water soluble sulphate concentrations in soils varied from 13 mg/l to 35 mg/l with soil pH values ranging from 8.3 to 8.9. Total sulphur concentration ranged from 0.01% to 0.06%.

Soil results indicate Design Sulphate Class DS-1 and Aggressive Chemical Environment for Concrete Class AC-1 should be used for design purposes on all shallow foundations across the site. Full chemical test results are available within Appendix C.



8. Generic Quantitative Risk Assessment

In accordance with Land Contamination Risk Management (LCRM EA, 2020), a Generic Quantitative Risk Assessment (GQRA) has been undertaken to determine the significance of the measured concentrations of contaminants identified during the ground investigation.

This involves undertaking an assessment of each potential contaminant linkage identified within the ICSM by comparing the contaminant concentrations against appropriate Generic Assessment Criteria (GAC).

GACs are screening criteria which are derived using a standard set of generic assumptions. They are designed to be broadly applicable to a wide range of site conditions and exposure scenarios. They must be appropriate and suitable for your site. The GACs used in this assessment represent “trigger values” that, if exceeded, could indicate a possibility of significant harm. However, these criteria do not represent the threshold at which there is a significant possibility of significant harm; this determination will normally require further investigation and / or Detailed Quantitative Risk Assessment (DQRA) is required and evaluation of risk to human health and controlled waters.

8.1 Human Health Risk Assessment

8.2.1 Assessment Criteria

Contaminant data has been compared to the Land Quality Management (LQM) / Chartered Institute of Environmental Health (CIEH) values published within ‘The LQM/CIEH Suitable for Use Levels (S4ULs) for Human Health Risk Assessment’ 2015. In brief, the document provides assessment criteria which have been derived in accordance with UK legislation, national as well as EA policy and using a modified version of the CLEA software and available guidance.

The S4ULs are considered appropriate for use in this assessment for organic contaminants and the Soil Organic Matter (SOM) content has been taken into consideration where appropriate.

Criteria for a limited number of contaminants have been derived by the Department for Environment, Food and Rural Affairs (DEFRA; UK government) in their document entitled SP1010: Development of Category 4 Screening Levels (C4SL) for Assessment of Land Affected by Contamination, April 2014. The National Planning Policy Framework states that ‘after development, as a minimum, land should not be capable of being determined as contaminated land under Part 2A of the Environmental Protection Act 1990’. Therefore, by inference, the C4SLs are appropriate for use in the planning context. It is generally accepted that assessment criteria for metals are not sensitive to changes in soil organic content (SOM). The C4SLs have therefore been adopted as assessment criteria in this report for the listed metals within the SP1010.

8.1.2 Soil Chemical Data in Comparison to GACs

The soil samples recovered from the site have been compared to appropriate GACs for a residential end use with plant uptake. When in comparison, none of the samples of topsoil or natural subsoils identified any exceedances of the GAC and will therefore not be considered further.

8.1.2 Asbestos

A total of 9 No. samples recovered from the topsoil on site were screened for the presence of asbestos. Although CC’s are not available for asbestos, the results indicate that no trace of asbestos was identified in any samples tested and will therefore not be considered further.



8.2 Controlled Waters Risk Assessment

The controlled waters risk assessment considers the potential impact of on-site contamination to the relevant controlled water receptors identified within the ICSM. These are summarised as follows:

Secondary A Aquifer – Wolston Sand and Gravel
Secondary Undifferentiated Aquifer – Oadby Member
Secondary B Aquifer – Gunthorpe Member
Field boundary drainage ditch.

8.2.1 Assessment Criteria

The approach adopted to assessing risks to Controlled Waters is based principally on considering the concentrations of contaminants identified within groundwater / leachate samples obtained in comparison to relevant GAC.

Several Water Quality Standards (WQS) have been applied as Generic Assessment Criteria (GAC), these include Water Framework Directive standards and thresholds (WFD), the Freshwater Environmental Quality Standards (EQS), the UK Drinking Water Quality Standards (DWQS) and WHO Guidelines for Drinking Water Quality values which have been used as initial conservative GAC to assess whether further assessment or discussion in terms of the risks to controlled waters is required.

Contaminant concentrations that exceed the applied GAC are then considered in the context of the site's environmental setting as to whether further qualitative or quantitative assessment is required.

8.2.1 Evaluation of Risk to Controlled Waters

During the investigation, no significant evidence of contamination was identified below the site and no evidence of Made Ground was identified.

Based on the above, no specific leachate testing, groundwater analysis or risk assessment has been included as part of this assessment. The risk to groundwater associated with the site is considered very low and no further risk assessment or discussion is considered to be warranted in that regard.

As a measure of good practice, any materials excavated and stockpiled on site should be positioned to take into consideration the potential for surface water / leachate run-off to impact the pond on site / surface water drains. Control measures should comprise keeping the sides of stockpiles at a low gradient to minimise surface water run-off and appropriate measures to prevent the ingress of suspended solids into surface waters.

8.3 Property and Infrastructure Risk Assessment

8.3.1 Building Materials

Risks to building materials associated with aggressive ground conditions is addressed in Section 7.15 of this report.

Soil results indicate Design Sulphate Class DS-1 and Aggressive Chemical Environment for Concrete Class AC-1 should be used for design purposes on all shallow foundations across the site.



8.3.2 Potable Water Supply Pipes

Contamination testing has not identified chemical contaminant concentrations within soils on the site in terms of a residential end use.

The investigation requirements for the selection of potable water pipe material are set out in UKWIR Report 10/WM/03/21 "Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites (UKWIR, 2010)".

This report has specific investigation requirements and as such detailed investigation of proposed utility routes was not within the scope of this investigation. However, based on current information conventional plastic water supply pipes are likely to be suitable

It is however, recommended that the contamination test results are made available to the relevant water company to allow design of any required potable water supply pipe work to be undertaken and to confirm requirements for any further assessment.

8.3.1 Ecological Risk Assessment

Soil results were compared to phytotoxic guideline values as outlined in Table 1 within BS3882:2007. No elevated contaminants were identified therefore the probability of phytotoxic contaminants affecting vegetation is considered unlikely.

The risk to ecological receptors is anticipated to be negligible given the concentrations encountered in the soils. However, the impact to ecological receptors from proposed construction activities should always be considered.



9. Ground Gas & Vapour Risk Assessment

9.1 Ground Gas Monitoring

Gas and groundwater monitoring has been carried out on 6 No. monitoring visits to date between 23rd December 2021 and 23rd March 2022 at atmospheric pressures ranging between 983mb to 1025mb, the results of which are summarised in Section 6-5.

The monitoring data is presented in Appendix E. The ground gas risk assessment and recommendations are presented below.

9.2 Ground Gas Risk Assessment Methodology

The risk to end users from ground gas has been assessed in accordance with the methodology presented in the following referenced documents:

British Standard BS8576:2013 – Guidance on investigations for ground gas – permanent gases and Volatile Organic Compounds (VOCs).

British Standards BS8485+A1:2019 – Code of practise for the design of protective measures for methane and carbon dioxide ground gases for new buildings.

CIRIA C665: Assessing risks posed by hazardous ground gas to buildings, 2007.

9.3 Gas Screening Value (GSV)

Both the CIRIA Report and the British Standard require the calculation of a Gas Screening Value (GSV). This is calculated as the maximum recorded percentage gas concentrations multiplied by the maximum gas flow rate. Where concentrations or flow rates less than the limit of detection on the analyser have been recorded, the limit of detection has been used (0.1% for gas concentration, 0.1 l/hr for gas flow rates).

The main method of characterising a site is using the method proposed by Wilson and Card (1999) and can be used for all types of development except for conventional low-rise housing with a ventilated underfloor void. The method uses both gas concentrations and borehole flow rates to define a characteristic situation for a site based on the limiting borehole gas volume flow for methane and carbon dioxide.

The GSVs and corresponding characteristic situation is summarised below in Table 9-1 which has been reproduced from Table 8.5 presented within CIRIA C665 and Table 2 within BS8485.

Table 9-1 Gas Screening Value Thresholds – Modified Wilson & Card Classification

CIRIA – No Sub-floor Void		Risk Classification	Additional Factors
Characteristic Situation	GSV (CH ₄ & CO ₂)		
CS1	<0.07	Very low risk	Typically, methane <1 % and / or carbon dioxide <5 %. Otherwise consider increase to CS2.
CS2	<0.7	Low risk	Borehole air flow rate not to exceed 70l/hr. Otherwise consider increase to CS3.



CIRIA – No Sub-floor Void		Risk Classification	Additional Factors
Characteristic Situation	GSV (CH ₄ & CO ₂)		
CS3	<3.5	Moderate risk	
CS4	<15	Moderate to high risk	Quantitative risk assessment required to evaluate scope of protective measures.
CS5	<70	High risk	
CS6	>70	Very high risk	

The NHBC have also developed a characterisation system that is similar to the Wilson and Card system, but is specific to low-rise housing with a clear ventilated underfloor void. This is a risk-based approach that is designed to allow an identification of gas protection for a low-rise housing development by comparing the measured gas emission rates to generic “traffic lights” scenarios. The traffic light system also includes “typical maximum concentrations” and are provided for initial screening purposes and risk-based gas screening values (GSVs) for consideration in situations where the typical maximum concentrations are exceeded. The “typical maximum concentrations” can be exceeded in certain circumstances should the conceptual site model indicate it is safe to do so. This is where professional judgement will be required, based on a thorough understanding of the gas-regime identified at the site where monitoring in the worst temporal conditions has occurred.

The CIRIA 665 report author (Steve Wilson) since provided further clarification regarding which guidance should be adopted for residential houses that have suspended cast in-situ concrete floor slab; for the avoidance of doubt, it was confirmed that the NHBC GSVs within the CIRIA 665 guidance should be adopted. The NHBC GSVs and typical maximum concentrations are summarised below in Table 9-2 reproduced from Table 8.7 presented within CIRIA C665.

Table 9-2 Gas Screening Value Thresholds - NHBC Traffic Light System

NHBC – Sub-floor Void			Methane Typical Maximum Concentrations (% v/v)	Carbon Dioxide Typical Maximum Concentrations (% v/v)
Classification	GSV (CH ₄)	GSV (CO ₂)		
Green	<0.16	<0.78	1	5
Amber 1	<0.63	<1.56	5	10
Amber 2	<1.56	<3.13	20	30
Red	>1.56	>3.13	-	-

However, it should also be recognised that the GSV thresholds in the above tables, are guideline values and not an absolute threshold and that the guideline GSV can be exceeded in certain circumstances should the CSM indicate it

is safe to do so and should not generally be exceeded without completion of a detailed gas risk assessment taking into account site-specific conditions.

For the purpose of this assessment, gas screening values have been calculated using only the worst-case hazardous gas concentrations and flow rates from the entire gas monitoring data set obtained to date.

During monitoring, numerous boreholes have displayed flooded response zones. Gas standpipes with flooded response zones can exhibit measurements of elevated gasses or display unrepresentative peak flow rates due to a build-up of pressure caused by rising water trapping the gas within the solid section of pipe. As such, some of the flow rates recorded on the first monitoring visit are likely attributable to a build-up of pressure in flooded response zones and are not considered to present a continued source of ground gas flow at surface. The gas monitoring data obtained from boreholes which had flooded response zones on the first monitoring visit has therefore been discounted for the purpose of this assessment, as the data is not considered representative of the actual conditions.

On the remainder of the visits, flooded response zones were noted in WS07, WS08, WS10 and WS16. However, to facilitate ground gas monitoring, each of these boreholes was bailed dry and was left to stabilise for a period prior to gas monitoring as the response zones were no longer flooded. The data is therefore considered valid and has been used within the dataset.

The calculated GSVs are presented in the table below.

Table 9-3 Calculated GSV

Max. Methane (% v/v)	Max. Carbon Dioxide (% v/v)	Max. Gas Flow Rate (l/hr)	Methane GSV (l/hr)	Carbon Dioxide GSV (l/hr)	NHBC Traffic Light System	Characteristic Situation
0.3	2.6	2.5	0.0075	0.065	Green	CS1

9.4 Ground Gas Protection Recommendations

Based on the gas monitoring undertaken to date, the calculated gas screening values for the site would indicate a 'Green' classification under the NHBC Traffic Light System and CS-1 in accordance with BS8485:2015+A1:2019. Therefore at this stage, based on the available monitoring data, it is considered that gas protection measures will not be required for the site.

Based on the gas monitoring results obtained, the concentrations of ground gases are not considered to be at a level which would pose any tangible risk to the health of construction workers working in an external environment at surface level.

Working within confined spaces should however be avoided wherever possible, however if this work is unavoidable then the works should be carried out in strict accordance with the confined spaces regulations to include gas monitoring during the works.

9.5 Radon Protection Measures

Radon protection measures are not required.

9.6 Vapour Risk and Membranes

No evidence of vapours has been noted during the intrusive investigation, as such the risk associated with vapours arising from the site is considered negligible. No further assessment is considered warranted in that regard.



10. Revised Environmental Risk Assessment

In accordance with the requirements of LCRM 2020, the S-P-R potential contaminant linkages identified by the intrusive investigation are discussed below. All remaining contaminant linkages identified within the ICSM have been discounted as no plausible contaminant linkage has been identified.

A summary of the findings is presented below.

10.1 Identified Sources

Based on the GQRA that has been carried out within Section 7.0, potential sources of contamination that could impact on the identified receptors are summarised below.

Low concentrations of sulphates in sub-soils.

10.2 Identified Pathways

Direct contact of buried concrete with aggressive ground.

10.3 Identified Receptors

Buried concrete.

10.4 Revised CSM and Potential Contaminant Linkages

Based on the above, the revised CSM is presented in Table 10-1 below.

Appropriate remedial / mitigation measures to break the potential contaminant linkages are discussed where required.

The revised CSM is provided in the table below.



Table 10-1 Revised CSM.

Contaminant Linkage	Source (S)	Pathway (P)	Receptor (R)	Probability	Consequence	Current Risk	Mitigation Measures
Property and Infrastructure							
1	On Site S2: Natural subsoils with low sulphate concentrations.	P6: Direct contact with aggressive ground.	R6: Buried concrete & structures	Unlikely	Mild	Very Low	Design Sulphate Class DS-1 and Aggressive Chemical Environment for Concrete Class AC-1 should be used for design purposes.

11. Conclusions & Recommendations

This Geo-Environmental Assessment is based upon the findings of an intrusive site investigation undertaken in December 2021 and January 2022.

It is understood that the site is proposed to be developed for a residential end use.

The Geo-environmental assessment has produced the following key conclusions and recommendations which should be implemented as part of the future redevelopment of the site to ensure suitability for the proposed end-use and to meet the requirements of planning.

Environmental Risk Assessment Summary	
Human Health Risk Assessment	Based on the contamination testing that has been carried out on the site, the risk assessment has indicated that the site poses a negligible risk to Human Health receptors. The natural topsoil and subsoils are considered to be suitable for retention / re-use on site if geo-technically suitable, subject to compliance with a Materials Management Plan (MMP).
Controlled Waters Risk Assessment	During the investigation, no significant evidence of contamination was identified below the site and no evidence of Made Ground was identified. The risk to groundwater / surface water associated with the site is considered very low to negligible and no further risk assessment considered to be warranted in that regard.
Ground Gas / Vapour Risk	Based on encountered ground conditions, gas protection measures are not considered to be required for the site. This recommendation should be confirmed with the relevant authorities prior to construction. No evidence vapours have been identified on site; no further assessment or mitigation is therefore required in that regard.
Ecological Risk	Potential impacts from contamination sources is considered negligible. However, the impact to ecological receptors from proposed construction activities should always be considered.
Geotechnical Assessment Summary	
Foundations	Traditional strip / trenchfill foundations are generally considered appropriate for the proposed development bearing within firm to stiff cohesive and medium dense to dense granular deposits encountered beneath the site, subject to consideration of the loads imposed. An allowable design bearing pressure of 100kN/m² is recommended for trenchfill foundations (up to 1m wide), bearing uniformly in the firm cohesive deposits at a depth of 1m. An allowable design bearing pressure of 125kN/m² is recommended for trenchfill foundations (up to 1m wide), bearing uniformly in the firm to stiff cohesive deposits and/or the medium dense to dense granular deposits at a depth of 2m. At this stage, based on the illustrative site layout a significant number of plots are situated in close proximity to the site boundaries / on-site hedgerows and therefore foundation depths are likely to exceed 2.5m due to tree influence. In addition, unstable and /or low strength strata have been encountered within the southeast of the site. It is considered likely that plots coinciding with these areas will likely require a piled foundation solution.



<i>Floor Slabs</i>	At this stage it is anticipated that both ground bearing and suspended floor slabs may be suitable for the site, subject to developer preference and further assessment of proposed ground levels / tree influence.
<i>Drainage</i>	The cohesive geology encountered across the site would suggest that soakaway drainage is not considered feasible; an alternative drainage solution is therefore likely to be required. The advice of a Drainage Engineer should however be sought to confirm this preliminary assessment prior to construction.
<i>Concrete</i>	Soil results indicate Design Sulphate Class DS-1 and Aggressive Chemical Environment for Concrete Class AC-1 should be used for design purposes on all shallow foundations across the site.
<i>Roads & Hardstanding</i>	Based on the ground conditions identified and testing undertaken, it is considered that a preliminary CBR design values of 2 - 5% should be achieved for road construction design purposes for near surface deposits underlying the site.
Recommendations	
Delineation of any soft cohesive deposits and / or loose granular deposits identified within which coincide with proposed plots.	
Limited SI was undertaken within the northern field (WS04 – WS06) and within the southern central portion of the site. It is recommended that further SI is undertaken in these locations to obtain further ground data.	
Detailed foundation design.	
Further in-situ CBR testing is recommended at formation level once development proposals have been established.	
The drilling of deeper boreholes may be required to aid the design of piled foundations.	
Re-use of materials on-site should be controlled by a CL:AIRE approved Materials Management Plan (MMP).	



12. References

The following documents are referenced in the report;

1. Desk Study Report, (GRM) dated August 2019.
2. Land Contamination Risk Management (LCRM) 2020 <https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm>
3. British Standards Institution (BSI) BS 10175:2015 Investigation of Potentially Contaminative Sites Code of Practice 2015.
4. BS 5930 'Code of Practice for Site Investigations' 2015+A1:2020.
5. BS EN ISO 22476-3:2005+A1:2011; Geotechnical investigation and testing. Field testing. Standard penetration test.
6. BS1377: 1990, Methods of Test for Soils for Civil Engineering Purposes.
7. BS EN ISO 17892:2014+ Geotechnical investigation and testing – Laboratory Testing of Soil.
8. BRE Digest 365 'Soakaway Design' 2016.
9. BS 8582:2013: Code of practice for surface water management for development sites.
10. CIRIA-R143-the-Standard-Penetration-Test-SPT-Methods-and-Use-1995.
11. BRE Special Digest 1 'Concrete in Aggressive Ground 2005'
12. BS3882:2015 Specification for Topsoil.
13. CL:AIRE SP1010 Development of Category 4 Screening Levels for Land Affected by Contamination (Rev 2) dated 24th September 2014.
14. The LQM/CIEH Suitable 4 Use Levels published 2015.
15. UKWIR Report 10/WM/03/21 "Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites (UKWIR, 2010)".
16. BS8576:2013 – Guidance on investigations for ground gas – permanent gases and Volatile Organic Compounds (VOCs).
17. BS8485:+A1:2019 – Code of practise for the design of protective measures for methane and carbon dioxide ground gases for new buildings.
18. Construction Industry Research and Information Association (CIRIA). 2008. Assessing the risk posed by hazardous gases to buildings. C665.



Drawings

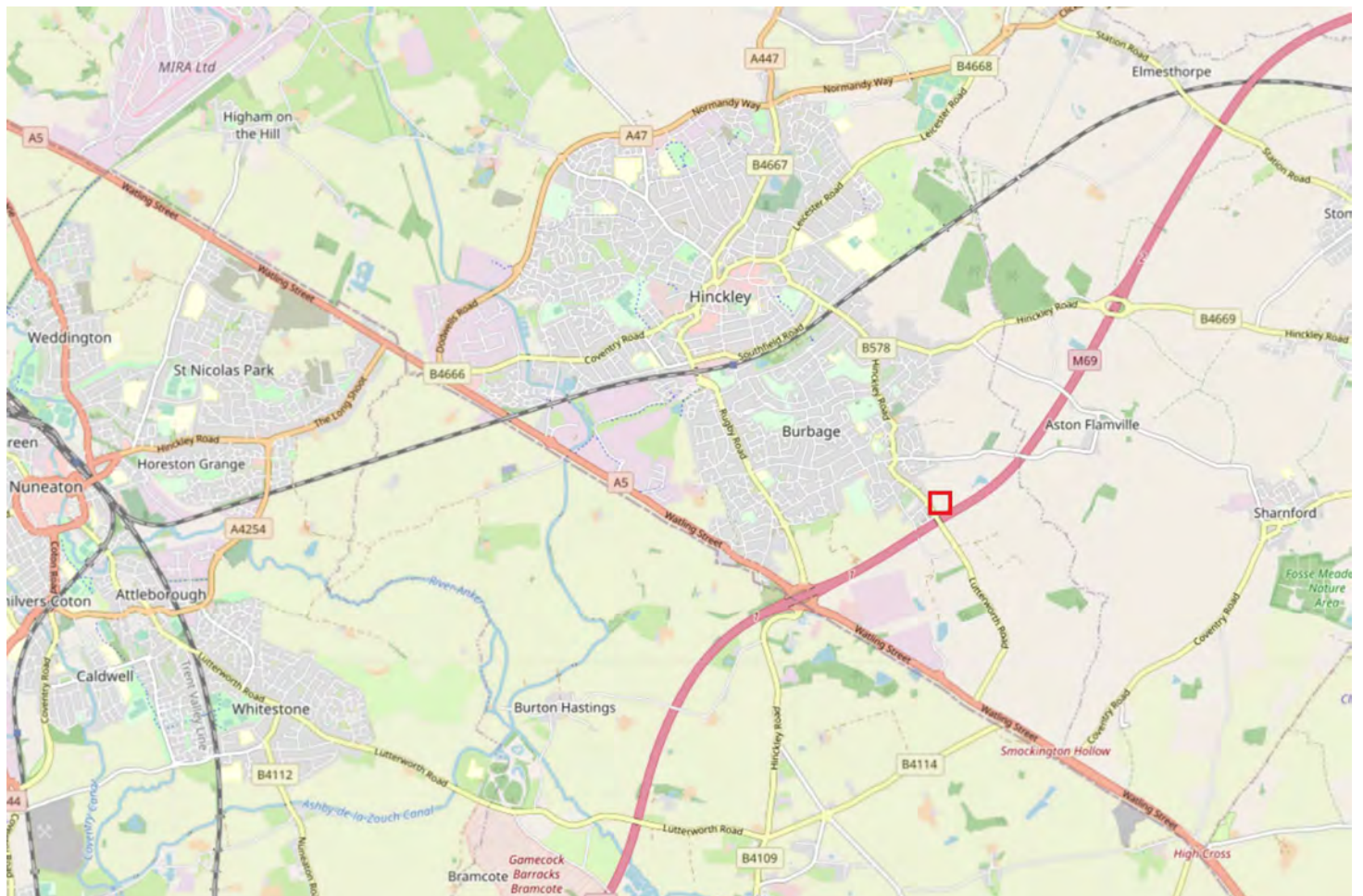
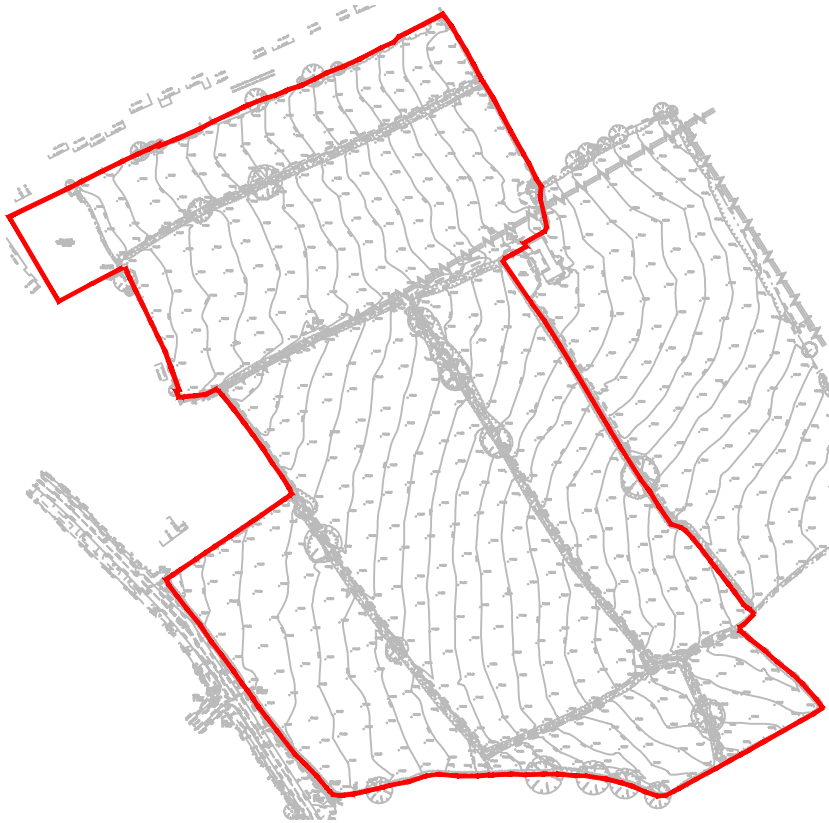
PJSG21-08-DR-001 –Site Location Plan

P17-1701_96-1C – Illustrative Masterplan

PJSG21-08-DR-002 – Site Features Plan

PJSG21-08-DR-003 – Exploratory Hole Location Plan





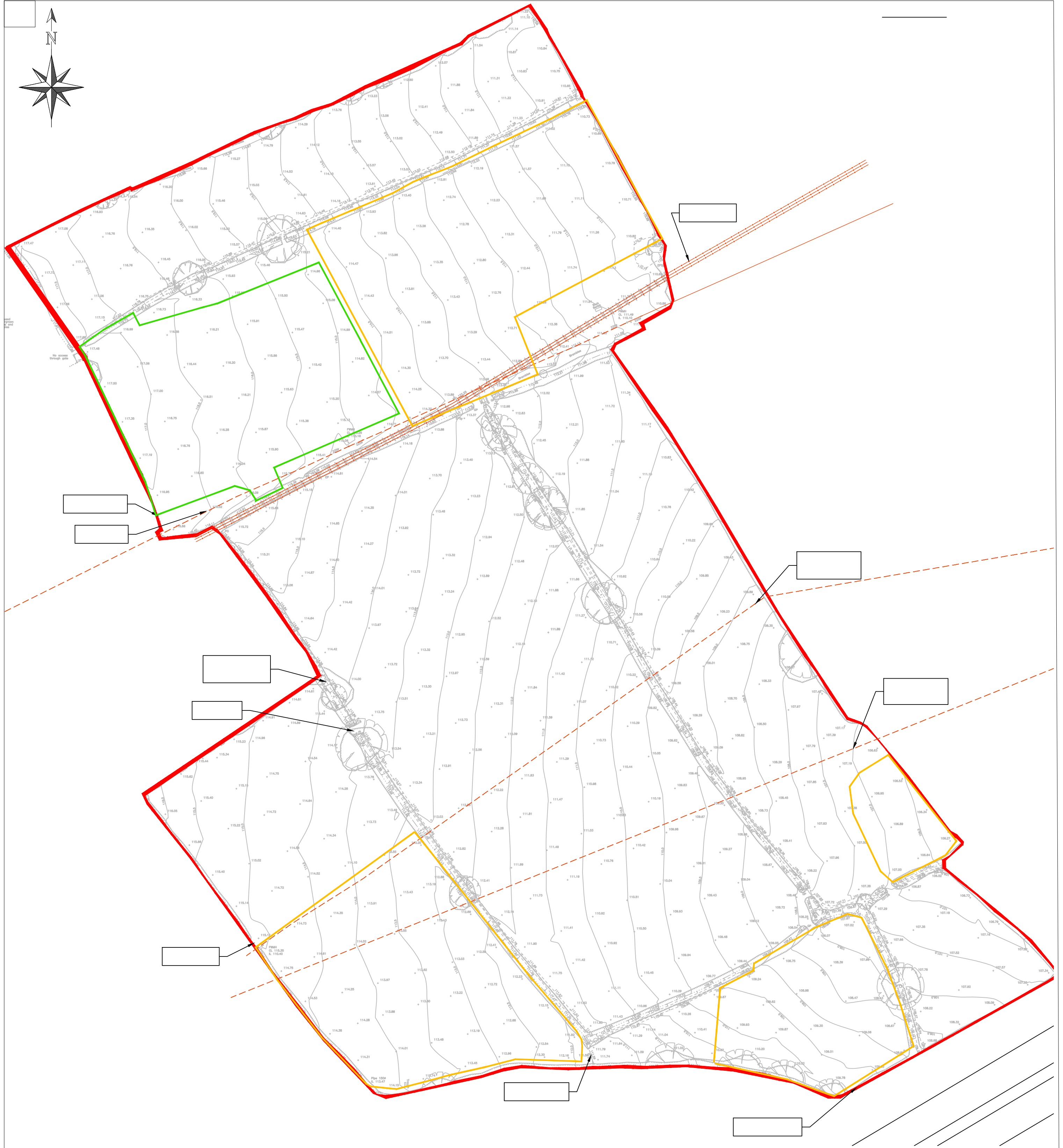
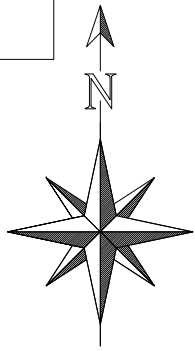


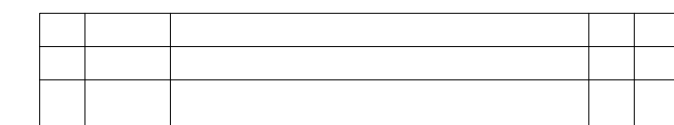
DESIGN PRINCIPLES:

1. Primary vehicular and pedestrian access off Lutterworth Road;
2. Key arrival space;
3. Retained Ridge and Furrow;
4. All existing vegetation subject to survey;
5. Proposed landscape planting;
6. Drainage attenuation basins; and
7. Proposed access serving neighbouring field.

LEGEND:

	Application Boundary		Proposed landscaping		Vehicular Access		Retained Ridge and Furrow
	Primary Road (adopted)		Public Open Space		Key / Landmark buildings		
	Lanes (private)		Play Space		Retained Public Right of Way		
	Existing Trees (subject to survey)		Proposed dwellings		Proposed pedestrian links		





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Appendix A: Site Photographs



Site Walkover Photographs.

PJSG21-58

Lutterworth Road, Burbage

Davidsons Homes



Photo no. 1	
Date 09.12.21	
Description:	Photograph of the access point to the site on Lutterworth Road.

Photo no. 2	
Date 09.12.21	
Description:	Photograph looking towards the south of the western field.

Site Walkover Photographs.

PJSG21-58

Lutterworth Road, Burbage

Davidsons Homes



Photo no. 3	
Date 09.12.21	
Description:	Photograph showing access into the central field.

Photo no. 4	
Date 09.12.21	
Description:	Photograph looking towards the north of the site.

Site Walkover Photographs.

PJSG21-58

Lutterworth Road, Burbage

Davidsons Homes



Photo no.

5

Date

09.12.21



Description:

Photograph of the southern boundary looking towards the M69.

Photo no.

6

Date

09.12.21



Description:

Photograph of dry ditch along field boundary of central field.