

GEO**MATTERS**



PHASE I & II AREA AT HOLBEACH MEADOWS, HOLBEACH

PHASE I & II
GEO-ENVIRONMENTAL INVESTIGATION
FOR
ASHWOOD HOMES

Project No:
GML16197

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PHASE I & II AREA AT HOLBEACH MEADOWS, HOLBEACH

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Executive Summary

This presents the salient points of the report and should not be referred to in isolation. The conclusions and recommendations presented below are considered reasonable based on the findings of the site investigation. However, these cannot be guaranteed to gain regulatory approval and therefore copies of this report should be sent to the appropriate Regulatory Authorities and / or other organisations (as appropriate) by the Client for their comments and approval prior to undertaking any irrecoverable works associated with the subject site.

Enabling / Earthworks	<p>Significant enabling works are not envisaged at this stage.</p> <p>Specific testing (e.g. waste acceptance criteria testing) may be required at the discretion of the Client's designated waste handler if the off-site movement / disposal of soils is undertaken. Where applicable, such requirements must be verified directly with them by the Client.</p>
Foundations	<p>Shallow soil conditions at the site are highly variable. Due to the very low in situ soil strengths which have been recorded, a maximum net allowable bearing capacity of 50kN/m² should be achievable in the underlying undisturbed natural soils across the eastern half of the site outside the influence of trees. Due to the higher in situ soil strengths which have been recorded in the western half of the site, a maximum net allowable bearing capacity of 90kN/m² should be achievable in the underlying undisturbed natural soils outside the influence of trees. Due to the low SPT test data reported alternative foundation options must be considered for this development construction in this part of the site. Specialist contractor may need to be consulted with regards to a specialist foundation solution if piles are required. Further works may be required by the contractor.</p> <p>All foundations should be deepened through topsoil / made ground and locally soft / loose soils; if / where encountered; to bear on the underlying undisturbed natural soils at a minimum depth of 0.90m below the influencing distance of trees. Because of the variability encountered in soil types, it is recommended that light mesh reinforcement is provided within all foundations.</p> <p>Foundations may require deepening within the influencing distance of trees at this stage (see Section 12.5).</p>
Floor Slabs	<p>Ground bearing floor slabs are considered appropriate across the majority of the site at this stage with suspended floors required only where more than 600mm of made ground has been encountered. Additionally a clear void and heave precautions will be required if deepening due to trees in excess of 1.50m depth which may have an effect on bearing capacity.</p>
Road Construction	<p>CBR values of less than 2% can be anticipated in the made ground and values between 2% and 5% can be anticipated in the underlying natural soils subject to in situ testing. All road construction proposals should be agreed with the Local Authority prior to finalising designs.</p>
Groundwater	<p>Significant groundwater was not encountered within the exploratory holes undertaken across the site during the recent investigation. Dewatering etc. is therefore not considered likely at this stage subject to prevailing weather / groundwater conditions.</p>
Building Near Trees	<p>Test data indicates that cohesive soils at the site have a maximum low volume change potential which will need to be considered during construction. Foundation designs will therefore need to be adjusted with regard to building near trees in accordance with NHBC Standards (Chapter 4.2).</p>

Drainage	At this stage the site is not considered to be suitable for the use of in situ drainage soakaways due to the predominantly cohesive nature of the natural soils encountered (which is likely to prevent any in situ permeability / infiltration) and inconsistent levels of groundwater present. All drainage proposals are subject to in situ testing and should be agreed with the Local Authority prior to finalising designs.
Mining	No precautions necessary.
Excavations	Generally poor stability was noted in the exploratory holes completed across the site for the short time they remained open with sidewall collapse noted in some areas from 1.20m depth. All excavations should be assumed to be unstable as a precautionary measure. No man entry into unsupported excavations should therefore be allowed without an appropriate risk assessment by the Client and / or their appointed site contractors. Reference to CIRIA report 97 (1983) should be made to establish a suitable means of support or battering of excavation sides.
Ground Gas & Radon	<p>The property is not in a radon affected area, as less than 1% of properties are above the action level in accordance with the Site Specific Environmental Data Report (Appendix IV). Radon protective measures are therefore not necessary for new properties, subject to Local Authority approval.</p> <p>A ground gas monitoring programme (6 No. weeks) is currently being undertaken for the site. Significant gas concentrations and / or flows have not been detected at present and therefore additional gas protection measures would not be required at this stage based on C665 (i.e. site indicatively classified as CS/1 or NHBC 'Green').</p>
Sulphate Classification	The pH values recorded from the soil samples retrieved from site averaged 8.8, indicating that generally near neutral soil conditions prevail within soils at the site. Water soluble sulphate analysis of the soils recovered from the site by Geo-Matters Ltd recorded soils to have concentrations ranging between <0.01g/l and 0.41g/l therefore DS-1/AC-1 conditions prevail at the site in accordance with BRE Special Digest 1 'Concrete in Aggressive Ground 2005'. Minimum concrete specification should be in accordance with NHBC Standards, Section 2.1, Table 1.
Contamination	Chemical analysis results have been compared with current relevant guidance which indicates that there are no elevated levels of contaminants present across the site. No issues have been identified in relation to the proposed residential end use with private gardens, subject to the approval of the Local Authority.
Remediation	Remediation works to protect human health are not considered necessary.
Topsoil	<p>Topsoil was encountered during the recent site works which has been chemically proven to be suitable for re-use. There shouldn't be a requirement to import additional topsoil onto the site for use in private gardens etc., although it is reiterated that any such works must be undertaken in full compliance with all regulatory licensing procedures, and validation of the soils prior to importation will be required, subject to the approval of the Local Authority.</p> <p>Where topsoil is discussed herein (and where it has been recorded within Engineer's logs for this site) it has been described and classified in general accordance with prevailing logging practice (e.g. BS5930 / ISO14688). Additional inspection(s) and analyses will be necessary should classification of such material be required against standards such as BS3882: 2007 'Specification for Topsoil and Requirements for Use'.</p>

<p>Further Works</p>	<p>The following further works are considered necessary:</p> <ul style="list-style-type: none"> • Trees and hedgerows are present around the site, therefore as some parts of the site are underlain by natural cohesive soils which have been recorded to have a low volume change potential, a topographical survey and arboricultural survey of the site and surrounding influencing area will be required in order to prepare a foundation schedule. This foundation schedule should be prepared once the development layout has been finalised in order to mitigate the effects of existing / proposed trees and landscaping. • A review of the foundation depths / bearing capacities will be required once the foundation schedule is prepared to confirm risks from locally soft / loose soils at depth in some areas of the site. • Verification of foundation proposals with local regulatory authorities and structural engineers; • Specialist foundation contractors are likely to require additional works to enable them to provide the most cost effective foundation proposal; • The Client will need to liaise with appropriately licensed waste management contractors to determine requirements for additional analysis etc. should materials be considered for off-site removal / disposal.
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The executive summary given above is an overview of the key findings and conclusions of the report. There may be other information contained in the body of the report which puts into context the findings of the executive summary. No reliance should be placed on the executive summary until the whole report has been read in full.

1.0 INTRODUCTION

1.1 Preamble

Geo-Matters Ltd were appointed by Ashwood Homes (hereafter referred to as 'the Client') to undertake a Phase I & II Geo-Environmental Assessment of the Phase I & II Area at Holbeach Meadows, Holbeach (hereafter referred to as 'the site').

1.2 Report Status

This report provides factual geotechnical and environmental information, alongside associated construction issues and recommendations, in relation to a proposed redevelopment of the site for new build residential houses (see Section 1.5 below).

This report has been prepared for the sole use and reliance the Client and their appointed agent, Geo-Matters Ltd. No other third party may rely upon or reproduce the content of this report without the written approval of Geo-Matters Ltd. If any unauthorised third party comes into possession of this report, they rely upon it entirely at their own risk and the authors do not owe them any warranty, duty of care or skill.

1.3 Sources and Conditions

The findings and recommendations made in this report are based on published information (as referenced in Section 3 and at the end of this report). Geo-Matters Ltd cannot accept responsibility for the reliability and authenticity of published information or reports prepared by third parties.

The possibility of significant variation in ground conditions existing between sampling locations cannot be discounted. Confirmation of ground conditions between exploratory holes should be undertaken if deemed necessary. There may be other conditions prevailing on site which have not been revealed by this investigation and which have not been taken into account in this report. Responsibility cannot be accepted for any conditions not revealed by this investigation and assessment. It should be noted that groundwater levels and quality may vary due to seasonal and other effects.

An arboriculturalist / invasive plant species survey has not been undertaken by Geo-Matters Ltd although potential areas of concern have been highlighted where observed. Invasive plant species may not have been fully observed due to seasonal variations and /or other restrictions.

Where topsoil is discussed herein (and where it has been recorded within Engineer's logs for this site) it has been described and classified in general accordance with prevailing logging practice (e.g. BS5930 / ISO14688). Additional inspection(s) and analyses will be necessary should classification of such material be required against standards such as BS3882: 2007 'Specification for Topsoil and Requirements for Use'.

Whilst this report may be utilised by others for reference purposes at the Client's discretion, it has not been prepared for any other purposes (e.g. waste classification etc.) and therefore additional works may be required by third parties dependent upon their own requirements / works. Further such assessments or testing may be required to inform subsequent works which we have not been made aware of or instructed upon at this stage (e.g. removal of soils for disposal etc.).

1.4 Previous Reports

Geo-Matters Ltd have not been made aware of any previous reports relating to the site by the client.

1.5 Proposed Development

This report has been prepared on the understanding that the development proposals for the site comprise new build low-rise residential housing with private gardens. Extracts of the proposed development plan (RG+P drawing 'Indicative Site Layout' dated May 2014) are presented in the Proposed Site Layout Plan (Drawing 001) in Appendix I. This shows residential housing across the majority of the investigation area, with public open space / soft landscaping in some areas and a watercourse / attenuation feature centrally positioned.

Should the development proposals alter (e.g. layout, type or foundation option), then the recommendations in this report may be subject to change. Whilst it may be utilised by others for reference purposes at the Client's discretion, it has not been prepared for any other purposes (e.g. waste classification etc.) and therefore additional works may be required by third parties dependent upon their own requirements / works.

2.0 SITE LOCATION AND DESCRIPTION

2.1 Location

The site is accessed via Fen Road, which is located to the east. The site is situated approximately 1.1km to the south west of Holbeach Town Centre, as presented on the Site Location Plan (Drawing 002) in Appendix II. The site is roughly centred at National Grid Reference 53551, 323938.

2.2 Description

The following general observations have been made concerning the site:

2.2.1 Site:

- The site is approximately 15.73ha in size and currently comprises 4 No. open agricultural fields;
- Agricultural fields are present adjacent to the site's boundaries on all sides;
- An old river (drain) is noted trending along the eastern boundary of the site;
- The site appears to be accessed through adjacent fields;
- The majority of site boundaries are defined by fencing and hedgerows including semi-mature trees;
- There is a disused barn located on the northern boundary of the site;
- An abandoned house is located adjacent to the barn on the northern boundary.

A Site Features Plan showing the general aspects of the site is included in Appendix III (Drawing 003).

2.2.2 Surrounding Area:

- The site is set within a mixed residential and agricultural area on the outskirts of Holbeach;
- Land to the north-east of the site supports a small office development;
- Land to the north, east and west supports agricultural fields;
- Land to the south supports residential housing.

3.0 GEO-ENVIRONMENTAL SETTING

3.1 Geology, Hydrogeology and Mining

A review of the following information has been undertaken:

- British Geological Survey 1:50,000 Scale Mapping Sheet 144 Solid & Drift;
- Coal Mining Searches, The Law Society Guidance Notes and Directory 1998 Edition;
- Environment Agency Online Aquifer Designation Database (accessed October 2016);
- Site Specific Environmental Data Report (Ref. GEO-M-3360535 dated October 2016).

Table 3.1: Geological Information

Drift Deposits	The superficial deposits beneath the site is recorded to comprise Tidal Flat Deposits. This is generally recorded to comprise clay and silt with sand and gravel layers.
Solid Geology	The solid geology beneath the site is recorded to comprise West Walton Formation. This is generally recorded to comprise mudstone and siltstone.
Ground Workings	There are thirteen no. records of ponds within a 250m radius of the site, the nearest of which is 7m east. All such records date from at least 65 years ago or more. There is one record of a burial ground 9m north of the site and one brick works 250m north-east.
Discontinuities	None recorded beneath the site on available mapping.
Artificial Ground	There are no records of any artificial ground within a 250m radius of the site.
Soil Chemistry	Soil chemistry for the site does not highlight any elevated natural contaminants.
Hydrogeology & Hydrology	<p>The solid geology is recorded as a 'Unproductive' Aquifer.</p> <p>There are no groundwater abstraction licences within a 250m radius of the site.</p> <p>There are no surface water abstraction licences within a 250m radius of the site.</p> <p>There are no potable water abstraction licences within a 250m radius of the site.</p> <p>No river quality (biological or chemical) is recorded within a 250m radius of the site.</p> <p>There are six no. surface water features recorded within a 150m radius of the site.</p> <p>The site is not recorded to lie within an Environment Agency 'Source Protection Zone.</p>

Table 3.1: Geological Information (Continued)

Flooding	The site is recorded to be within an Environment Agency flood risk area. Accordingly, the risk of flooding is recorded as 'Medium'.												
Natural Ground Stability Hazards	<p>The site has been classified as having the following hazard ratings:</p> <table> <tr> <td>Shrinking / Swelling Clay</td><td>- Low</td></tr> <tr> <td>Landslide</td><td>- Very Low</td></tr> <tr> <td>Ground Dissolution</td><td>- Negligible</td></tr> <tr> <td>Compressible Ground</td><td>- Moderate</td></tr> <tr> <td>Collapsible Ground</td><td>- Negligible</td></tr> <tr> <td>Running Sand</td><td>- Moderate</td></tr> </table>	Shrinking / Swelling Clay	- Low	Landslide	- Very Low	Ground Dissolution	- Negligible	Compressible Ground	- Moderate	Collapsible Ground	- Negligible	Running Sand	- Moderate
Shrinking / Swelling Clay	- Low												
Landslide	- Very Low												
Ground Dissolution	- Negligible												
Compressible Ground	- Moderate												
Collapsible Ground	- Negligible												
Running Sand	- Moderate												
Mining	The Site-Specific Environmental Data Report (included within Appendix IV) indicates that the site is not set within an area at risk from coal mining.												
Radon	The property is not in a radon affected area, as less than 1% of properties are above the action level in accordance with the Site Specific Environmental Data Report (Appendix IV).												

3.2 Environmental Data Search

The principal considerations of immediate relevance within a 250m radius of the site are given in Table 3.2 overleaf. For a comprehensive list of environmental data, please refer to the site specific environmental data report presented in Appendix IV.

Table 3.2: Environmental Data

Historic Industrial Sites	
Potentially Contaminative Uses	There are thirteen records identified within a 250m radius of the site. Two of which are railway sidings, the closest of these is located on site, two records of nurseries the closest of which is 9m north east, one record of a burial ground 9m north, one unspecified depot located 141m north of the site, one unspecified tank 197m south, three records of railway stations / buildings one coalyard 204m north of that site, one unspecified commercial / industrial 22m north and one brick works 250m north east of the site.
Tanks	Two unspecified tanks are recorded, the closest of which is 129m to the north of the site. There are no other tanks recorded within a 250m radius of the site.
Energy Features	None identified within a 250m radius of the site.
Infilled Land	There are nine identified within a 250m radius of the site. There are seven no. records of ponds within a 250m radius of the site, the nearest of which is 7m east. There is one record of a burial ground 9m north of the site and one brick works 250m north east.
Fuel and Garage Sites	There are two identified within a 250m radius of the site. Both records are recorded as garages, the closest of which is 157m east of the site.
Environmental Permits, Incidents and Registers	
IPC Authorisations	None identified within a 250m radius of the site.
IPPC Authorisations	None identified within a 250m radius of the site.
Water Industry Referrals	None identified within a 250m radius of the site.
Red List Discharge Consents	None identified within a 250m radius of the site.
List 1 Dangerous Substances	None identified within a 250m radius of the site.
List 2 Dangerous Substances	None identified within a 250m radius of the site.
Part A & Part B Activities and Enforcements	None identified within a 250m radius of the site.
Licensed Discharge Consents	None identified within a 250m radius of the site.

Table 3.2: Environmental Data (Continued)

Planning Hazardous Substance Consents	None identified within a 250m radius of the site.
National Incidents, List 1 & 2	None identified within a 250m radius of the site.
Category 3 or 4 Radioactive Substances Authorisations	None identified within a 250m radius of the site.
Site determined Contaminated under Part 2A EPA 1990	None identified within a 250m radius of the site.
Landfills and other Waste Sites	
Landfills (BGS, Historical or Local Authority)	There are two identified within a 500m radius of the site. Both records are recorded as environment agency historic landfills, the closest of which is 406m south west of the site.
Waste Facility / Treatment Operations	None identified within a 250m radius of the site.
Current Land Use	
Current Industrial Data	There are five records of potentially contaminative industrial sites within 250m of the study site. These refer to two motoring companies (the nearest of which 122m south east of the site), a signs company (122m south east of the site), a generic tanks company (122m north of the site) and an industrial products company (194m north west of the site).
Petrol Filling Stations / Garages	No active PFS entries have been identified within a 250m radius of the site.
Underground High Pressure Oil and Gas Pipelines	None identified within a 250m radius of the site.
Sensitive Land Use	
World Heritage Sites	None identified within a 250m radius of the site.
Other Entries	None identified within a 250m radius of the site.

4.0 HISTORY OF LAND USE

A study of historical Ordnance Survey maps has been undertaken to identify any potentially contaminative former land-uses. The main historical features of the site and surrounding area (within a 250m radius) are summarised in Table 4.1 (below) and Table 4.2 (overleaf) and are shown on the historical maps presented in Appendix V. It should be noted, however that considerable periods of time may have elapsed between successive Ordnance Survey map editions and it is possible that further land uses have occurred in the intervening years which were not recorded. In these circumstances, whilst we have tried to ascertain the complete record of the site history, the possibility that other significant land uses may have taken place cannot be discounted.

Table 4.1 Principal Historical On-Site Features

OS map date(s)~	Source Scale	Principal On-Site Features
1887	1:10,560	The site is situated across several open fields which are divided by hedgerows and trees along the boundaries. Two ponds are shown within the north-eastern section of the site, and 'Old River' runs along the eastern boundary.
1888	1:2,500	No significant changes identified.
1903	1:10,560	No significant changes identified.
1903 - 1906	1:10,560	
1904	1:2,500	The ponds are now no longer shown within the north-eastern area.
1929	1:10,560	An orchard / plantation is shown across the far western fields.
1931 - 1932	1:2,500	No significant changes identified.
1938	1:10,560	No significant changes identified.
1950	1:10,560	Elongated structure (possible barn) present in centre of site adjacent to track.
1955 - 1958	1:10,560	No significant changes identified.
1968	1:2,500	No significant changes identified.
1970 - 1971	1:10,000	Orchard no longer shown.
1981 [#]	1:2,500	No significant changes identified.
1986 [#]	1:2,500	No significant changes identified.
1991 [#]	1:2,500	No significant changes identified.
1992	1:10,000	No significant changes identified.
1995	1:2,500	Elongated structure no longer recorded.
2002	1:10,000	No significant changes identified.
2010	1:10,000	Buildings absent from the centre of site.
2014	1:10,000	No significant changes identified.

[#] Historical map incomplete

Table 4.2 Principal Historical Off-Site Features

OS map date(s)~	Source Scale	Principal Off-Site Features	Direction
1887	1:10,560	Fields. Farm. Ponds. 'Holbeach Station'. Railway. Brick works. Residential housing. Pump.	ALL N N N NE NE N N,S
1888	1:2,500	No significant changes identified.	-
1903 - 1906	1:10,560	Brick works removed. Ponds removed.	NE N
1904	1:2,500	No significant changes identified.	-
1929	1:10,560	Residential housing.	E
1931 - 1932	1:2,500	Holbeach flour mills	NE
1938	1:10,560	No significant changes identified.	-
1950	1:10,560	No significant changes identified.	-
1955 - 1958	1:10,560	Pump removed.	S
1968	1:2,500	Hallgate nurseries	N
1970 - 1971	1:10,000	Station removed. Railway dismantled. Depot / Coal yard.	N N N
1981 [#]	1:2,500	No significant changes identified.	-
1986 [#]	1:2,500	No significant changes identified.	-
1991 [#]	1:2,500	Nurseries removed.	N
1992	1:10,000	Railway removed. Residential development.	N N
1995	1:2,500	No significant changes identified.	-
2002	1:10,000	Depot removed.	N
2010	1:10,000	No significant changes identified.	-
2014	1:10,000	No significant changes identified.	-

[#] Historical map incomplete

5.0 PHASE I GEOTECHNICAL ASSESSMENT

5.1 Anticipated Ground Conditions

Soils – Made Ground/Topsoil

On the basis of available information, cultivated topsoil is anticipated across the majority of the site given the absence of other extensive significant historical land uses. Made ground may be expected around access areas / tracks etc.

Natural Strata

The site is recorded to be underlain by solid geology which is considered likely to have weathered to a cohesive soil (clay and silt) at shallow depths, although granular soils may also be present.

Groundwater

The solid geology beneath the site has been categorised as an 'Undefined' aquifer. Significant groundwater is therefore not anticipated during site works, depending on the prevailing weather conditions, ambient conditions groundwater etc.

Stability Issues (e.g. Mining / Slopes)

The site has been classified as having:

Hazard	Maximum Designated Rating
Shrinking / Swelling Clay	Low Hazard Rating
Landslide	Very Low Hazard Rating
Ground Dissolution	Negligible Hazard Rating
Compressible Ground	Moderate Hazard Rating
Collapsible Ground	Negligible Hazard Rating
Running Sand	Moderate Hazard Rating

No coal mining issues have been identified at this stage.

Ground Gas and Radon

Potential ground gas sources have been identified at this stage, with regards to the two historic landfill sites located within 500m of the site.

The property is not in a radon affected area, in accordance with the Site Specific Environmental Data Report (Appendix V). Radon protective measures are therefore not necessary for new properties.

Contamination and Performance of Building Materials

Following a review of available records, no potentially contaminative land uses have been identified on the site at this stage. Issues relating to contamination are therefore subject to laboratory testing, final layout proposals and regulatory discussions.

6.0 PHASE I ENVIRONMENTAL ASSESSMENT

6.1 Phase I Conceptual Model

The following is based on the desk study information listed above and the site assessment undertaken by Geo-Matters Ltd.

6.1.1 Site Summary:

A review of all available desk study information indicates that the site has supported open farm land / fields since the earliest mapping reviewed.

The surrounding area is recorded to have been progressively and partially developed from similar open fields to support some residential and office land uses, whilst remaining predominantly agricultural.

Potential ground gas sources have been identified at this stage, with regards to the two historic landfill sites located within 500m of the site.

No significant potentially contaminative land uses have been recorded on site or within an influencing distance.

6.1.2 S-P-R Characterisation:

The statutory guidance describes contaminated land in terms of 'significant pollutants' and 'pollutant linkages', using SOURCE-PATHWAY-RECEPTOR' scenarios for the site. For a pollutant linkage to exist all three of these elements must be present. These have been clearly defined in the guidance as follows:

.....potential source as 'a contaminant which is in, or under the land and which has the potential to cause significant harm or to cause pollution of controlled waters'.

.....potential pathway as 'one or more routes or means by, or through, which a receptor is being exposed to, or affected by a contaminant, or could be so exposed or affected'.

.....potential receptor as 'a living organism, a group of living organisms, an ecological system or a piece of property which is being or could be, harmed by a contaminant or controlled waters which are being, or could be, polluted by a contaminant'.

Examination of the desk study information has identified the following (see below):

Potential Sources:

The review of the available desk study information has revealed the following potential sources of contamination identified resulting from former and/or existing land uses that must be considered in a SOURCE-PATHWAY-RECEPTOR scenario. There is also though the possibility that naturally occurring levels of some contaminants may exceed the relevant guidance values.

Table 6.1 Potential Sources of Contamination

Potential Onsite Sources	Associated Potential Contaminants ^{a,b}	
	<i>Metals and Inorganics</i>	<i>Organics and Others</i>
Farmland	General Suite	Pesticides
Potential Offsite Sources		
Farmland	General Suite	Pesticides

^a Professional experience alongside DoE Industry Profiles and CLR8 (withdrawn but used for reference)

^b Subject to Local Authority comments / planning conditions

Potential Pathways:

- Direct ingestion of soil and dust;
- Dermal contact with soil and dust;
- Inhalation of vapour and dust;
- Made ground (if identified);
- Vadose zone.

Potential Receptors:

- Ground workers employed in the redevelopment of the site;
- Future end users of the site (including properties);
- Controlled waters;
- Neighbouring land users.

6.1.3 Potential Pollutant Linkages:

A potential pollutant linkage is defined as 'the relationship between a contaminant, a pathway and a receptor' where the pollutant is the contaminant in the pollutant linkage. For land to be identified as contaminated under the current UK guidance all three elements of the pollutant linkage must be present. In many cases there may be more than one pollutant linkage on any given site.

A review of the desk study information, the features noted in the site visit and the potential sources, pathways and receptors listed above has led to the following potential significant pollutant linkages (SPL) being considered (Table 6.2 below).

Table 6.2 Potential Pollutant Linkages

Potential Source	Pathway	Receptors					SPL*
		Controlled Waters	Ground workers	End-users	Flora	Building materials	
Metal/metalloids and inorganics in SOIL	Direct Ingestion		✓	✓			✓
	Dermal Contact		✓	✓			✓
	Inhalation		✓	✓			✓
	Leaching/direct movement				✓	✓	✓
Asbestos containing materials in SOIL	Inhalation		✓	✓			✓
Organics in SOIL (hydrocarbons, pesticides, PAH etc)	Direct Ingestion		✓	✓			✓
	Dermal Contact		✓	✓			✓
	Inhalation		✓	✓			✓
	Leaching/direct movement				✓	✓	✓
Metal/metalloids and inorganics In CONTROLLED WATERS	Direct Ingestion	✓	✓	✓	✓		✓
	Dermal Contact	✓	✓	✓	✓		✓
	Inhalation						
	Leaching/direct movement	✓	✓	✓	✓		✓
Organics in CONTROLLED WATERS (hydrocarbons, pesticides, PAH etc)	Direct Ingestion	✓	✓	✓	✓		✓
	Dermal Contact	✓	✓	✓	✓		✓
	Inhalation						
	Leaching/direct movement	✓	✓	✓	✓		✓
GROUND GAS (Carbon Dioxide and Methane)	Direct Ingestion						
	Dermal Contact						
	Inhalation		✓	✓			✓
	Leaching/direct movement						

* Potential SPL identified pending Local Authority comments and confirmation of ground conditions

6.1.4 Model Status and Uncertainty

The potential significant linkages listed above are based on available data reviewed to date. Therefore, the linkages identified are tentative in nature and are subject to the following uncertainties:

- Presence and nature of any made ground and the underlying strata;
- Presence and depth of any groundwater at shallow depth;
- Actual presence of contaminants or ground gas sources in soils and / or water.

7.0 RATIONALE FOR PHASE II INVESTIGATION

7.1 Scope of Ground Investigation

The Phase II Environmental Investigation will comprise the recovery of samples from all exploratory holes positioned to provide optimum coverage across accessible areas of the site as identified in Table 7.1 below, in general accordance to BS5930:2015. Samples will be selected for analysis on the basis of their onsite visual descriptions with particular attention given to samples displaying any olfactory evidence of contamination. All samples will be taken in snap top plastic containers and 250ml amber glass jars or vials. All samples will be placed in cooled containers and transported to Geo-Matters Ltd's storage facility in Castle Donington before awaiting transfer to a UKAS / MCERTS accredited laboratory.

Table 7.1: Exploratory Hole Layout Rationale

Potential Source / Issue	Exploratory Holes
General Site Coverage	All Holes

The samples taken during the intrusive investigation will be analysed for a range of contaminants in accordance with NHBC Standards Chapter 4.1 'Land Quality – managing ground conditions' and CLR 8 'Potential Contaminants for the Assessment of Land' (withdrawn but used for reference purposes where applicable). The soil samples will be analysed for the following parameters: arsenic, cadmium, chromium, copper, nickel, zinc, lead, mercury, selenium, chromium, sulphate, speciated PAH's and phenols. Selected samples shall also be analysed for asbestos (screen), pesticides and TPH. If samples are observed to display further visual or olfactory evidence of contamination (e.g. evidence of hydrocarbon staining or potential asbestos containing materials), then they shall be scheduled for appropriate additional analysis.

7.2 Scope of Geotechnical Investigation

The geotechnical investigation will comprise the advancement of exploratory locations across accessible areas of the site to determine the site's geomorphological characteristics. The visual description of the soils will be used as the basis of determining the basic engineering properties of the soils encountered and all soils logging will be in accordance to BS5930:2015 where applicable.

During site works, samples will be collected; where necessary; to allow for classification testing and chemical analysis to be undertaken to determine the potential effects of soil upon the performance of building materials. *In situ* testing (SPTs) will also be taken where possible to allow strength profiling of the underlying strata.

8.0 SITE WORKS

All fieldwork and soil descriptions were carried out in general accordance with BS EN 14688 'Geotechnical Investigation and Testing – Identification and Classification of Soil' and/or BS5930:2015. Each of the exploratory locations was positioned on site by Geo-Matters Ltd. The locations of these exploratory holes are shown on the Site Investigation Plan presented in Appendix VII (Drawing 005). Prior to any excavation, the locations were checked with the Client for the presence of underground services and with reference to service plans where supplied.

8.1 Scope of Investigation

A summary of the ground investigation undertaken by Geo-Matters Ltd is outlined in the table below:

Table 8.1: Method of Investigation

Method of Investigation	No.	Max Depth (m)	Sampling Regime
Bore Hole Drilling	14	700	1 & 2
Trial Pits	38	3.90	1 & 2

¹ – 500ml plastic tubs, 250ml amber jars and 40ml glass vials.

² – Bulk bags.

The investigation was carried out under the supervision of an engineer from Geo-Matters Ltd.

Disturbed samples were collected from each discrete horizon within the exploratory holes (where possible) to provide soils for laboratory testing.

Exploratory Hole Logs are presented in Appendix VIII.

8.2 Limitations to the Investigation

No significant limitations were encountered during the recent site investigation works.

9.0 ANALYSIS, RESULTS AND INTERPRETATION

9.1 Chemical Analyses of Soils

In December 2014 DEFRA released a set of provisional 'Category 4 Screening Levels' (C4SLs) for a select number of determinands. These were provisional screening values which were intended to indicate a level at which land may be considered as 'suitable for use' and 'definitely not contaminated'. Third parties (e.g. LQM, CIEH etc.) have used DEFRA's risk assessment approach and methodology to calculate further screening values for additional determinands which are common to brownfield / redevelopment sites across the UK. These are based on a limited number of common land uses, including residential end-uses with / without gardens. A combined set of Tier 1 Screening Values (T1SVs) shall therefore be used in consideration of potential risks to future end users at the subject site with reference to the proposed residential end use with gardens.

Due to ongoing revisions to the contaminated land assessment framework (including the derivation and release of authoritative screening values), the following assessment (and related conclusions / recommendations) may be revised should replacement screening values etc. be released in the near future.

Representative soil samples from the exploratory locations were analysed for the range of contaminants outlined above. Representative samples of the near surface and underlying natural strata were analysed. The environmental analysis was scheduled by Geo-Matters Limited and carried out by a UKAS/MCERTS accredited laboratory.

The full details of the chemical test results are presented in Appendix IX, and are summarised in Table 9.1 overleaf.

Table 9.1: Laboratory Analysis of Soil Samples

Determinand	No. of Samples Analysed	Concentration Range (mg/kg)	Tier 1 Screening Values (mg/kg)	No. Exceeding Threshold
Metals				
Arsenic	24	<1.0* – 23.0	37.0 ^a	0
Cadmium	24	<0.2*	22.0 ^a	0
Chromium (III)	24	7.7 – 39.0	910.0	0
Chromium (VI)	24	<4.0*	6.0 ^b	0
Lead	24	4.5 – 38.0	200.0 ^a	0
Selenium	24	<1.0* – 4.7	250.0 ^b	0
Nickel	24	7.3 – 33.0	180.0 ^b	0
Copper	24	6.6 – 29.0	2400.0 ^b	0
Zinc	24	19.0 – 87.0	3700.0 ^b	0
Mercury	24	<0.3* – 0.6	40.0 ^b	0
Organics and Inorganics				
TPH C ₆ -C ₁₀	6	<0.1*	27.0 ^b	0
TPH C ₁₀ -C ₂₅	6	<10.0*	74.0 ^b	0
TPH C ₂₅ -C ₄₄	6	<10.0*	1100.0 ^b	0
Benzo(a)pyrene	24	<0.1*	2.2 ^b	0
Asbestos	6	ND	D ^c	0
Phenols	24	<1.0*	280.0 ^b	0
pH	24	7.4 – 9.4	N/A	N/A
Water Sol. Sulphate (g/l)	24	0.012 – 0.41	N/A	N/A
Pesticides	6	ND	D ^c	0

^a DEFRA C4SL values for a residential end use with gardens / plant uptake

^b LQM 'S4UL' values for a residential end use with gardens / plant uptake

^c Geo-Matters general screening level

* - Contaminants all recorded below laboratory limits of detection

N/A = Not Applicable, ND = Not Detected, D = Detected, DL = Detection Limits

Metals

The results were compared with the referenced tier 1 screening values (T1SVs) which are considered most appropriate to the proposed end-use (residential with gardens).

Zootoxic Metals

None of the samples analysed for zootoxic metals recorded concentrations in excess of their respective Tier 1 Screening Values (T1SVs). On this basis, no risks have been identified from zootoxic metals at the subject site.

Phytotoxic Metals

None of the samples analysed for phytotoxic metals recorded concentrations that were deemed excessive. On this basis, no risks have been identified from these determinands at the subject site.

Inorganics

The pH values recorded from the soil samples averaged 8.8, indicating that generally near neutral soil conditions prevail within soils at the site.

*Organics**Total Petroleum Hydrocarbons (TPH)*

None of the samples analysed for TPH recorded concentrations in excess of their respective Tier 1 Screening Values (T1SVs). On this basis, no risks have been identified from these determinands at the subject site.

Organics

The significance of the PAH laboratory results have been assessed using the T1SV for benzo(a)pyrene. This is considered, in terms of toxicity, to present the greatest hazard to human health. The T1SV of 2.2mg/kg was not exceeded in any of the soil samples analysed. On this basis, no risks have been identified from these determinands at the subject site.

Other Determinands*Asbestos*

A selection of representative samples of made ground / topsoil were scheduled for the assessment of free fibres of asbestos. None of the samples analysed tested positive for asbestos fibres. On this basis, no risks have been identified from asbestos at the subject site based on the proposed residential end use.

General Contaminants*Visual, Olfactory and Field Measurements*

During our recent ground investigation, no significant visual or olfactory evidence of any potential contamination was noted within any the exploratory holes completed.

9.2 CLEA Statistical Analysis

In August 2008 the Environment Agency (EA) withdrew the core regulatory guidance documents for the assessment of human health risks from contaminated land (CLR7 to CLR10), including the soil guideline value (SGV) documents. The newly published EA guidance documents (SC050021.TR1, SC050021.SR2 and SC050021.SR3) have been consulted; alongside the CL:AIRE / CIEH guidance note on statistical interpretation of contaminated land data; and the risk assessment for the subject site has been undertaken in broad accordance with these documents.

With reference to the documents listed above, statistical analysis on sample data is not required for determinands where exceedances above the relevant T1SV were not recorded. Based on Table 4.1, no exceedances were recorded for any of the determinands analysed. Therefore, further statistical analysis is not considered necessary at this stage.

9.3 Geotechnical Testing

The geotechnical laboratory testing was carried out in accordance with BS EN 14688 'Geotechnical Investigation and Testing – Identification and Classification of Soil' and/or BS5930:2015. Full details of the test results are presented in Appendix IX.

The pH values recorded from the soil samples averaged 8.8, indicating that generally near neutral soil conditions prevail within soils at the site.

Three representative soil sample of the clay soil was analysed for Atterberg Limits and Moisture Contents. The results are presented in Table 9.2:

Table 9.2: Plasticity Index Results

Determinand	No. of Samples	Range	Remark
Plasticity Index	3	8.0 - 18.0%	N/A
% passing 425µm test sieve	3	100%	N/A

The results show that the clay soils encountered at the site display a modified plasticity indices between 8 - 18%. This indicates that the cohesive soils across the site would be classified as displaying a maximum **low** volume change potential.

Eleven representative sample of granular strata were scheduled for particle size distribution (PSD) grading analysis. The results confirm the engineer's site descriptions.

Copies of test certificates are presented within Appendix IX.

9.4 Ground Gas and Radon

Potential ground gas sources have been identified on / around the site therefore, ground gas monitoring exercise was undertaken concurrently with the site investigation works discussed herein. The monitoring programme (6 No. visits) is still ongoing at the time of writing but no significant levels of gas have been recorded at present (i.e. all concentrations of methane below 1% v/v and all concentrations of carbon dioxide below 5% v/v, with no significant flow detected).

Interpretation of gas monitoring data is specified in CIRIA 665 (2007) '*Assessing risks posed by hazardous ground gases to buildings*'. This guidance includes the calculation of volumetric flow rates of ground based on maximum recorded gas concentrations and maximum recorded gas flow rates. Limiting factors are applied to the gas monitoring results and a characteristic situation is then applied to the site. This provides a worst-case scenario in relation to the ingress of gas to future structures. Based on the current ground gas concentrations and flow rates detected to date the site would be indicatively classified as Characteristic Situation 1 or NHBC 'Green', subject to confirmation following completion of monitoring works and Local Authority / NHBC approval.

The property is not in a radon affected area, as less than 1% of properties are above the action level in accordance with the Site Specific Environmental Data Report (Appendix V). Radon protective measures are therefore **not necessary** for new properties, subject to Local Authority approval.

10.0 PHASE II GEOTECHNICAL ASSESSMENT

10.1 Ground Conditions

The geotechnical element of the works was undertaken concurrently with the environmental investigation. The ground conditions encountered within the exploratory locations are summarised in the table below with the logs presented in Appendix VIII.

Table 10.1: Summary of Ground Conditions at the Site

General Description	Maximum Thickness (m)
Brown slightly sandy slightly silty TOPSOIL with rootlets. (TP01 – TP38, WS01 – WS12, WS14)	0.30 (average 0.21)
MADE GROUND (Comprising: dark brown silty sandy clay). (WS13)	0.20
MADE GROUND (Comprising: light brown slightly gravelly silty sand. Gravel is fine to medium brick and tile fragments. (WS13)	0.80
Generally loose light brown silty fine to coarse SAND. (All holes)	3.80 (average 1.87*)
Tidal flat deposits (TFD) comprising soft grey brown sandy sometimes clayey SILT / silty CLAY. (All holes)	6.30 (average 2.43*)

* Not fully penetrated at all locations

10.1.1 Soils – Made Ground / Topsoil

Made ground was encountered within one exploratory hole (WS13) that was completed during the recent intrusive works and generally comprised reworked topsoil brown silty clay with brick fragments.

Topsoil was encountered within all the remaining exploratory holes across the site and generally comprised brown sandy silt.

The made ground / topsoil encountered are **not** considered to be suitable bearing strata for the proposed development due to the variability of composition and strength associated with such materials.

10.1.2 Soils – Natural Strata

Tidal flat deposits (TFD) were recorded beneath the topsoil / made ground at all locations; comprising loose to medium dense light brown slightly silty SAND and grey soft to very soft sandy SILT.

The TFD is directly underlain by the West Walton Formation which was not encountered. Some *in situ* strength test data was noted to increase at around 7.00m begl, which may be potentially indicative of an interface / change of strata although no variation in soil type etc. was recorded within the borehole arisings at these 2 No. locations (WS02 and WS03).

10.1.3 Groundwater and Excavations

Groundwater strikes were recorded at 9 No. positions across the site during the recent works. These were recorded from depths ranging between 1.5m and 2.9m begl.

10.1.4 Stability Issues (e.g. mining / slopes)

Hazard	Maximum Designated Rating
Shrinking / Swelling Clay	Low Hazard Rating
Landslide	Very Low Hazard Rating
Ground Dissolution	Negligible Hazard Rating
Compressible Ground	Moderate Hazard Rating
Collapsible Ground	Negligible Hazard Rating
Running Sand	Moderate Hazard Rating

The Environmental Data Report for the site indicates that risks from mining are not likely at this stage. Precautions are **not** likely to be required at this stage, subject to regulatory approval.

10.2 Contamination and Performance of Building Materials

10.2.1 Sulphates

The pH values recorded from the soil samples retrieved from site averaged 8.8, indicating that generally near neutral soil conditions prevail within soils at the site.

Water soluble sulphate analysis of the soils recovered from the site by Geo-Matters Ltd recorded soils to have concentrations ranging between <0.01g/l and 0.41g/l therefore DS-1/AC-1 conditions prevail at the site in accordance with BRE Special Digest 1 'Concrete in Aggressive Ground 2005'.

10.2.2 Other Contaminants

No determinands were detected at concentrations considered sufficient to present risks to the building materials based on the proposed residential end use including private gardens.

10.3 Geotechnical Hazards for the Proposed Development

It is understood that the proposed development at the site is to comprise a residential end-use including private gardens and soft landscaping. Table 5.4 summarises the main; but not limited to; geotechnical hazards identified during our recent intrusive works associated with the proposed development.

Table 10.2: Summary of Geotechnical Hazards

Hazard	Comment
Volume Change Potential	Test data indicates that cohesive soils at the site have an overall low volume change potential which will need consideration for the proposed foundation design.
Made Ground	Significant depths of made ground were not generally encountered during the recent investigation works with the exception of WS13, therefore localised deepening may be required.
Soft / Loose Soils	Very loose / very soft soils have been encountered. Alternative foundation options (e.g. ground improvement or piles) may need to be considered for such areas. Further assessment from a geo-environmental engineer and specialist contractor may be required where this is the case. Groundwater will reduce the bearing capacity of the granular soils, where encountered.
Trees	Trees / hedgerows may have an effect on bearing depths, once a finalised plan has been received and engineering assessment can be undertaken.

Shallow soil conditions at the site are highly variable. Due to the very low *in situ* soil strengths which have been recorded, a maximum net allowable bearing capacity of 50kN/m² should be achievable in the underlying undisturbed natural soils across the eastern half of the site outside the influence of trees. Due to the higher *in situ* soil strengths which have been recorded in the western half of the site, a maximum net allowable bearing capacity of 90kN/m² should be achievable in the underlying undisturbed natural soils outside the influence of trees.

Due to the low SPT test data reported alternative foundation options must be considered for this development construction in this part of the site.

11.0 PHASE II ENVIRONMENTAL ASSESSMENT

11.1 Phase II Conceptual Model

11.1.1 Site Summary

The results of the scheduled chemical analysis were compared with the appropriate T1SVs based on the proposed residential end-use with private gardens.

In light of the chemical analysis results the SOURCE-PATHWAY-RECEPTOR characteristics have been re-assessed as outlined below.

11.1.2 Source-Pathway-Receptor Characterisation and Risk Assessment

The results of the chemical testing analyses indicate that no determinands have been recorded at concentrations sufficient to act as a source in a SOURCE-PATHWAY-RECEPTOR scenario (i.e. significant contamination was not encountered during our recent investigation works).

The potential pathways and receptors have therefore been revised from those listed in Section 6.1.3 above.

11.1.3 Identified Pollutant Linkages

In view of the above; the pollutant linkages have been reassessed as listed in Table 11.1 overleaf.

Table 11.1: Identified Pollutant Linkages

Potential Source	Pathway	Receptors					SPL*
		Controlled Waters	Ground workers	End-users	Flora	Building materials	
Metal/metalloids and inorganics in SOIL [#]	Direct Ingestion						
	Dermal Contact						
	Inhalation						
	Leaching/direct movement						
Asbestos containing materials in SOIL	Inhalation						
Organics in SOIL [#] (hydrocarbons, pesticides, PAH etc)	Direct Ingestion						
	Dermal Contact						
	Inhalation						
	Leaching/direct movement						
Metal/metalloids and inorganics in CONTROLLED WATER	Direct Ingestion						
	Dermal Contact						
	Inhalation						
	Leaching/direct movement						
Organics in CONTROLLED WATER (hydrocarbons, pesticides, PAH etc)	Direct Ingestion						
	Dermal Contact						
	Inhalation						
	Leaching/direct movement						
GROUND GAS (Carbon Dioxide and Methane)	Direct Ingestion						~
	Dermal Contact						~
	Inhalation						~
	Leaching/direct movement						~

* Subject to Local Authority approval

~ Subject to Local Authority approval / completion of monitoring programme

11.1.4 Model Status, Uncertainty and Justification

The above revised conceptual model is considered to represent the current site conditions based on the information derived from the site investigation.

11.2 Risk Assessment

11.2.1 Qualitative Risk Assessment

The regulatory framework within England which addresses risks from contaminated land is presented within and across several regimes. This includes sections 78 (A) to (YC) in Part IIA of the Environmental Protection Act 1990 (which was retrospectively inserted by Section 57 of the Environment Act 1995), Building Regulations, Environmental Permitting Regulations and the National Planning Policy Framework (NPPF). The contaminated land regime (principally under Part IIA of the EPA (1990)) sets out a risk based approach within which the identification and remediation of contaminated land presenting unacceptable risks to people and the environment is described. Related regimes (such as those listed above) provide additional guidance through frameworks which focus on specific subsequent scenarios (e.g. re-use of land for new uses).

In the context of the planning system (as identified within the NPPF), an emphasis is placed upon remediating and mitigating contaminated land (where appropriate). The NPPF states that (s. 120 pp28):

"To prevent unacceptable risks from pollution and land instability, planning policies and decisions should ensure that new development is appropriate for its location. The effects (including cumulative effects) of pollution on health, the natural environment or general amenity, and the potential sensitivity of the area or proposed development to adverse effects from pollution, should be taken into account. Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner."

And additionally:

"Planning policies and decisions should also ensure that:

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

The core legislation (Part IIA) adopts the principle of a 'suitable for use' approach for; the assessment of contaminated land, the derivation of a site-specific risk assessment and subsequent determination of a remedial strategy. Action is only required if unacceptable risks are posed to human health or to the environment, taking into account the current land-use and geo-environmental settings.

The legislation places a responsibility on the Local Authority to determine whether the land under its jurisdiction is contaminated by consideration of whether: -

- ***Significant harm is being caused;***
- ***There is a significant possibility of significant harm being caused; or***
- ***Pollution of controlled waters is being caused or is likely to be caused.***

The statutory guidance describes a risk assessment methodology in terms of 'significant pollutants' and 'pollutant linkages', using SOURCE-PATHWAY-RECEPTOR' scenarios for the site.

On the basis of available data, the geo-environmental setting and proposed end-use, a qualitative Source-Pathway-Receptor risk assessment table is presented overleaf.

Table 11.2: Qualitative Risk Assessment Summary Table

Source	Pathway	Target (Receptor)	Comments	Risk Level	Action*
Metals/ Metalloids in soils and dust	Direct ingestion (active) Inhalation (passive) Dermal contact.	Ground workers, End users	Significant contamination was not encountered	LOW	NO FURTHER ACTION REQUIRED
Metals/ Metalloids in soils and dust	Near surface soils	Plants within the proposed landscaped areas and gardens.	Significant contamination was not encountered	LOW	NO FURTHER ACTION REQUIRED
Metal / Metalloids compounds in waters	As above (plus skin contact)	Ground workers, Site users	Significant groundwater was not encountered	LOW	NO FURTHER ACTION REQUIRED
Inorganics in soils and dust	Direct ingestion (active) Inhalation (passive)	Ground workers, End users and the Property	Significant contamination was not encountered	LOW	NO FURTHER ACTION REQUIRED
Organic compounds in soils and dust	As above (plus skin contact)	Ground workers, Site users	Significant contamination was not encountered	LOW	NO FURTHER ACTION REQUIRED
Organic compounds in waters	As above (plus skin contact)	Ground workers, Site users	Significant groundwater was not encountered	LOW	NO FURTHER ACTION REQUIRED
Ground Gas	Inhalation (passive), Ingress	End users and Property	Significant sources not encountered	LOW	NO FURTHER ACTION REQUIRED~

Notes: LOW / MODERATE / HIGH - Risk level is assigned a low/moderate/high qualitative value, based on assessed requirement for action in context of Part II EPA 90.

* Subject to Local Authority Approval

~Subject to Local Authority approval / completion of monitoring programme

11.3 Site Status

The Phase II Conceptual Model and the Qualitative Risk Assessment outlined above indicate that soils at the site should be treated as uncontaminated in the context of the proposed re-development of the site for a residential land-use with private gardens, subject to regulatory authority approval.

12.0 RECOMMENDATIONS

The conclusions and recommendations presented below are considered reasonable based on the findings of the site investigation undertaken to date. However, these cannot be guaranteed to gain regulatory approval and therefore copies of this report should be sent to the appropriate Regulatory Authorities and / or other organisations (as appropriate) by the Client for their comments and approval prior to undertaking any irrecoverable works associated with the subject site.

12.1 Enabling / Earthworks: Significant enabling works are not envisaged at this stage.

Specific testing (e.g. waste acceptance criteria testing) may be required at the discretion of the Client's designated waste handler if the off-site movement / disposal of soils is undertaken. Where applicable, such requirements must be verified directly with them by the Client.

12.2 Foundations: Shallow soil conditions at the site are highly variable. Due to the very low *in situ* soil strengths which have been recorded, a maximum net allowable bearing capacity of 50kN/m² should be achievable in the underlying undisturbed natural soils across the eastern half of the site outside the influence of trees. Due to the higher *in situ* soil strengths which have been recorded in the western half of the site, a maximum net allowable bearing capacity of 90kN/m² should be achievable in the underlying undisturbed natural soils outside the influence of trees. Due to the low SPT test data reported alternative foundation options must be considered for this development construction in this part of the site. Specialist contractor may need to be consulted with regards to a specialist foundation solution if piles are required. Further works may be required by the contractor.

All foundations should be deepened through topsoil / made ground and locally soft / loose soils; if / where encountered; to bear on the underlying undisturbed natural soils at a minimum depth of 0.90m below outside the influencing distance of trees. Because of the variability encountered in soil types, it is recommended that light mesh reinforcement is provided within all foundations.

Foundations may require deepening within the influencing distance of trees at this stage (see Section 12.5).

12.3 Floor Slabs & Road Construction: Ground bearing floor slabs are considered appropriate across the majority of the site at this stage with suspended floors

required only where more than 600mm of made ground has been encountered. Additionally a clear void and heave precautions will be required if deepening due to trees in excess of 1.50m depth which may have an effect on bearing capacity.

CBR values of less than 2% can be anticipated in the made ground and values between 2% and 5% can be anticipated in the underlying natural soils subject to *in situ* testing. All road construction proposals should be agreed with the Local Authority prior to finalising designs.

12.4 Groundwater: Significant groundwater was not encountered within the exploratory holes undertaken across the site during the recent investigation. Dewatering etc. is therefore not considered likely at this stage subject to prevailing weather / groundwater conditions.

12.5 Building Near Trees: Test data indicates that cohesive soils at the site have an maximum low volume change potential which will need to be considered during construction. Foundation designs will therefore need to be adjusted with regard to building near trees in accordance with NHBC Standards (Chapter 4.2).

12.6 Drainage: At this stage the site is **not** considered to be suitable for the use of *in situ* drainage soakaways due to the predominantly cohesive nature of the natural soils encountered (which is likely to prevent any *in situ* permeability / infiltration) and inconsistent levels of groundwater present. All drainage proposals are subject to *in situ* testing and should be agreed with the Local Authority prior to finalising designs.

12.7 Ground Gas and Radon: The property is not in a radon affected area, as less than 1% of properties are above the action level in accordance with the Site Specific Environmental Data Report (Appendix IV). Radon protective measures are therefore not necessary for new properties, subject to Local Authority approval.

A ground gas monitoring programme (6 No. weeks) is currently being undertaken for the site. Significant gas concentrations and / or flows have not been detected at present and therefore additional gas protection measures would not be required at this stage based on C665 (i.e. site indicatively classified as CS/1 or NHBC 'Green').

12.8 Mining: No precautions necessary.

12.9 Excavations: Generally poor stability was noted in the exploratory holes completed across the site for the short time they remained open with sidewall collapse noted in some areas from 1.20m depth. All excavations should be assumed to be unstable as a precautionary measure. No man entry into unsupported excavations should therefore be allowed without an appropriate risk assessment by the Client and / or their appointed site contractors. Reference to CIRIA report 97 (1983) should be made to establish a suitable means of support or battering of excavation sides.

12.10 Sulphate Classification: The pH values recorded from the soil samples retrieved from site averaged 8.8, indicating that generally near neutral soil conditions prevail within soils at the site. Water soluble sulphate analysis of the soils recovered from the site by Geo-Matters Ltd recorded soils to have concentrations ranging between <0.01g/l and 0.41g/l therefore DS-1/AC-1 conditions prevail at the site in accordance with BRE Special Digest 1 'Concrete in Aggressive Ground 2005'. Minimum concrete specification should be in accordance with NHBC Standards, Section 2.1, Table 1.

12.11 Contamination: Chemical analysis results have been compared with current relevant guidance which indicates that there are no elevated levels of contaminants present across the site. No issues have been identified in relation to the proposed residential end use with private gardens, subject to the approval of the Local Authority.

12.12 Topsoil: Topsoil was encountered during the recent site works which has been chemically proven to be suitable for re-use. There shouldn't be a requirement to import additional topsoil onto the site for use in private gardens etc., although it is reiterated that any such works must be undertaken in full compliance with all regulatory licensing procedures, and validation of the soils prior to importation will be required, subject to the approval of the Local Authority.

Where topsoil is discussed herein (and where it has been recorded within Engineer's logs for this site) it has been described and classified in general accordance with prevailing logging practice (e.g. BS5930 / ISO14688). Additional inspection(s) and analyses will be necessary should classification of such material be required against standards such as BS3882: 2007 'Specification for Topsoil and Requirements for Use'.

12.13 Remediation: Remediation works to protect human health are **not** considered necessary.

12.14 Further Works: The following further works are considered necessary:

- Trees and hedgerows are present around the site, therefore as some parts of the site are underlain by natural cohesive soils which have been recorded to have a **low** volume change potential, a topographical survey and arboricultural survey of the site and surrounding influencing area will be required in order to prepare a foundation schedule. This foundation schedule should be prepared once the development layout has been finalised in order to mitigate the effects of existing / proposed trees and landscaping.
- A review of the foundation depths / bearing capacities will be required once the foundation schedule is prepared to confirm risks from locally soft / loose soils at depth in some areas of the site.
- Verification of foundation proposals with local regulatory authorities and structural engineers;
- Specialist foundation contractors are likely to require additional works to enable them to provide the most cost effective foundation proposal;
- The Client will need to liaise with appropriately licensed waste management contractors to determine requirements for additional analysis etc. should materials be considered for off-site removal / disposal.

INFORMATION SOURCES

Geological data	<p>British Geological Survey 1:50,000 Scale Mapping Sheet 144 Solid & Drift; Coal Mining Searches, The Law Society Guidance Notes and Directory 1998 Edition;</p> <p>Environment Agency Online Aquifer Designation Database (accessed October 2016);</p> <p>Site Specific Environmental Data Report GEO-M-3360536 dated October 2016).</p>
Environmental	<p>Site Specific Environmental Data Report: (Ref. GEO-M-3360535 dated October 2016).</p> <p>BRE Report BR211 "Radon: Guidance on protective measures for new dwellings" (1999 Edition).</p> <p>Environment Agency (EA) & DEFRA: "Model Procedures for the Management of Land Contamination – Contaminated Land Report 11" (CLR11) (2004)</p> <p>Department for Environment, Food and Rural Affairs (DEFRA) – "SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document" (December 2014)</p> <p>DEFRA and Contaminated Land: Applications in Real Environments (CL:AIRE) "SP1010 – Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination: Final Project Report" (Revision 2 dated 24th September 2014)</p> <p>Chartered Institute of Environmental Health (CIEH): "Professional Practice Note: Reviewing human health risk assessment reports invoking contaminant oral bioavailability measurements or estimates" (2009)</p> <p>CL:AIRE in Association with EIC and AGS: "Soil Generic Assessment Criteria for Human Health Risk Assessment" (updated January 2010 version) (Reference purposes)</p>
Historical	As presented Appendix V.