

P3159.1.0

Site at Battisford Hall, Church Road, Battisford, Stowmarket, IP14 2HG

Combined Phase 1 and Phase 2 Geo-environmental Report

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Part 1 of 4

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Combined Phase 1 and Phase 2 Geo-environmental Report

***Site at Battisford Hall, Church Road,
Battisford, Stowmarket, IP14 2HG***

Client Name: The Trustees of T A Harwood

Project Number: P3159.1.0

Date: 20 July 2018

ENABLING DEVELOPMENT

Client:	The Trustees of T A Harwood
Architect:	The Whitworth Co Partnership LLP
Site:	Battisford Hall, Battisford, Stowmarket, Suffolk, IP14 2HG.
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Executive Summary

The client, The Trustees of T A Harwood, commissioned agb Environmental to undertake a combined Phase 1 and Phase 2 geo-environmental investigation at Battisford Hall, Battisford, Stowmarket, Suffolk, IP14 2HG.

Development Proposals

The development proposals include the conversion of four barns to create five dwellings with private gardens and amenity space.

Site Reconnaissance

An old fuel pump was located to the south of the site, anecdotal evidence for a representative on site indicated there was a buried fuel tank nearby, however the exact location was not known. It was also indicated that a paraffin fuel above ground storage tank had been previously located to the east of the site.

The site comprised a series of partially overgrown barns with soft landscaping, and access tracks surfaced with hardcore or concrete. The barns were single or two-storey dilapidated timber framed structures clad with weatherboard, or brick built with tiled roofs; and had either concrete or bare earth floors. A cluster of barns named 'The Open Barn' covering area of approximately 45m by 25m toward the south-east corner. It is understood that the northern end of this building was used as a chemical store.

Site History

From at least 1884 the site has been within the grounds of Battisford Hall, with a series of buildings, probably stables or similar, are within the, roughly, southern half of the site. Several alterations to the barn layout have been complete up to the present.

Ground Conditions

The encountered ground conditions comprised Made Ground to depths between 0.20mbgl and 0.90mbgl underlain by the Lowestoft Formation to a depth of at least 5.00mbgl. Perched groundwater was encountered at a single location, the remaining boreholes were dry. During subsequent monitoring the perched groundwater was at depths of 3.16mbgl and 3.20mbgl.

Ground Contamination

When compared to the screening values for residential with plant uptake end use, the results of analysis recorded elevated concentrations of PAHs at a single location. Based on the findings of the Conceptual Site Model, a plausible source-pathway-receptor pollutant linkage has been identified. Soil remediation is therefore recommended.

The analysis of selected groundwater samples recorded elevated concentrations of lead and selenium in a single sample. However, the sample was perched groundwater which is unlikely to migrate laterally or vertically to nearby surface water features or the Principal Aquifer below due to and the relative impermeability and anticipated thickness of the superficial diamicton deposits.

Based on the gas screening value of <0.01l/hr and encountered ground conditions CIRIA C665 Characteristic Situation 1 is considered applicable to the site.

Recommendations

A Remediation Strategy (RS) should be produced detailing the remediation to be completed. However, prior to the RS it is recommended that a supplementary investigation is completed to confirm the extent of the affected soil, possibly reducing the area of soil remediation required. The outline soil remediation will consist of the removal of the contamination impacted Made Ground to a depth of 0.60mbgl or until the natural undisturbed soil is encountered, whichever is shallower, followed by its replacement with imported, certified clean, soil. Additional comments are provided in the report.

We would recommend that this report is forwarded to the relevant statutory consultees including the Environment Agency and Local Authority to seek their comments and subsequent approval prior to site works commencing.

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1 Introduction

The client, The Trustees of T A Harwood, commissioned agb Environmental to undertake a combined Phase 1 and Phase 2 geo-environmental investigation at Battsford Hall, Battsford, Stowmarket, Suffolk, IP14 2HG. The development proposals and purpose of investigation are detailed below.

1.1 Development Proposals

The development proposals include the conversion of four barns to create five dwellings with private gardens and amenity space. Available plans are provided in **Appendix 1**.

1.2 Purpose of Investigation

The objectives of the geo-environmental investigation were as follows:

Phase 1:

- Research the geology, hydrology and hydrogeology of the site;
- Research the history of the site and surrounding area;
- Collate statutory held records for historical and current potential sources of contamination;
- Identify the potential contaminant sources, the possible pathways and receptors; and
- Develop a preliminary conceptual site model (CSM) with preliminary risk assessment.

Phase 2:

- Establish the ground conditions;
- Undertake analysis of selected soil samples;
- Provide an updated conceptual site model (CSM) and risk assessment; and
- Provide outline geo-environmental recommendations.

The report has been formulated in general accordance with BS10175:2011+A2:2017 *Investigation into Potentially Contaminated Sites – Code of Practice*, CLR11 – *Model Procedures for the Management of Land Contamination*, and guidance from the National Planning Policy Framework.

2 Site Details

The location of the site, the topography, and site description are provided below.

2.1 Location and Topography

Battisford is located within a rural area approximately 4km south of Stowmarket, Suffolk. The site, an irregular shaped plot in the grounds of Battisford Hall, covers an area of 0.83ha and is centred at National Grid Reference 605626 254630. The site is at an elevation of approximately 60mOD, and the surrounding land dipped down to the south. A location plan is presented in **Appendix 1**.

2.2 Description

A walkover was completed on 21 June 2018, details are provided below, and selected photographs are presented in **Appendix 2**.

The site was accessed via a roughly 0.25km long driveway off Church Road to the south. It was immediately north of Battisford Hall and a large pond within a lawn island. An old fuel pump was located to the south of the site, anecdotal evidence for a representative on site indicated there was a buried fuel tank nearby, however the exact location was not known. It was also indicated that a paraffin fuel above ground storage tank had been previously located to the east of the site.

The site comprised a series of partially overgrown barns with soft landscaping, and access tracks surfaced with hardcore or concrete. The barns were single or two-storey dilapidated timber framed structures clad with weatherboard, or brick built with tiled roofs; and had either concrete or bare earth floors. Some of the barns had open sides. The barns included:

- 'The Piggery', roughly 15m by 12m building at the northern end of site;
- 'The Mill' Barn, roughly 16m by 8m, with lean-to, located east of centre;
- the roughly 'L' shaped 'The Grain Barn' that covered an area of 25m by 20m, with two corrugated metal sheet clad silos understood to be for grain storage at its northern end, was toward the south-west; and
- a cluster of barns named 'The Open Barn' covering area of approximately 45m by 25m toward the south-east corner. It is understood that the northern end of this building was used as a chemical store.

With reference to the site plan provided by the client, trees on and around the site include willow, hornbeam, chestnut, maple, birch, oak, holly, walnut, hawthorn, ash, coniferous (unspecified), and fruit (unspecified).

3 Geological Information

Salient information regarding anticipated ground conditions and ground permeability is summarised in the following sections. Unless otherwise noted, the following information has been obtained from public archives via the data supplier GroundSure; the GroundSure reports are presented in **Appendix 3**.

3.1 Anticipated Ground Conditions and Permeability

The anticipated superficial deposits, underlying solid geology and recorded Made Ground within 250m of the site are detailed in **Table 3.1**.

Table 3.1 Ground Conditions and Permeability

Item	Anticipated Ground Conditions	Recorded Permeability
Made/Artificial Ground	None recorded.	-
Superficial Deposits	The site is directly underlain by the Lowestoft Formation (diamicton).	Moderate to low with mixed flow type.
Solid Geology	The superficial deposits are underlain by the solid geology of the Newhaven Chalk Formation. The overlying Red Crag Formation is indicated 11m north-west.	Newhaven Chalk Formation: Very high permeability with fracture flow type. Red Crag Formation: High permeability with intergranular flow type.

Nearby historical boreholes logs recorded on the British Geology Survey (BGS) website indicate that the thickness of the superficial deposits overlying the bedrock to be at least 18m.

3.2 Radon

Information regarding radon is provided in **Table 3.2**.

Table 3.2 Radon

Item	Details
Radon Affected Areas	The site is not within a radon affected area, as less than 1% of properties are above the action level as defined by the Health Protection Agency (HPA).
Radon Protection	No radon protective measures are considered necessary for new properties or extensions as described in Building Research Establishment (BRE) publication BR211.

3.3 Geological Hazards

Based on information provided by the BGS, the risk of geological hazards affecting the site is summarised in **Table 3.3**.

Table 3.3 Geological Hazards

Hazard	Distance/Direction	Hazard Rating
Shrink-swell clays	On site	Low
Landslides	On site	Very low
Ground dissolution of soluble rocks	On site	Negligible
Compressible deposits	On site	Negligible
Collapsible deposits	On site	Very low
Running sands	On site	Very low

4 Hydrogeology and Hydrology

Salient information regarding aquifers, licensed groundwater abstractions, source protection zones (SPZs), surface water features and flooding within 250m of the study site is summarised below.

4.1 Aquifer

Details regarding aquifers beneath the site are detailed in **Table 4.1**.

Table 4.1 Aquifers

Item	Distance/Direction	Designation
Superficial Deposits	On site	Secondary (undifferentiated) Aquifer.
Solid Geology	On site	Principal Aquifer.

The institute of Geological Sciences *Hydrogeological Map of East Anglia, Sheet 1* (1981) indicates an approximate ground water level within the chalk Principal Aquifer of 30mOD, which is approximately 30mbgl.

4.2 Abstraction Licences

Recorded abstraction licences within 250m of the site are detailed in **Table 4.2**.

Table 4.2 Abstraction Licences

Item	Distance/Direction	Details
Groundwater Abstraction	On site	Detail: General farming and domestic. Status: Historical.
Surface Water Abstraction	-	None recorded.
Potable Water Abstraction	-	None recorded.

4.3 Source Protection Zones and Groundwater Vulnerability

Details of SPZs and groundwater vulnerability within 250m of the site are summarised in **Table 4.3**.

Table 4.3 Source Protection Zones and Groundwater Vulnerability

Item	Distance/Direction	Classification / Soil Vulnerability Category
SPZs	On site	Total Catchment, Zone 3.
SPZs within Confined Aquifers	-	None recorded.
Groundwater Vulnerability and Leaching Potential	On site	Minor Aquifer/Intermediate Leaching Potential (I1) / Minor Aquifer/High Leaching Potential (L)

4.4 Water Network / Surface Water Features

Details of water network entries and surface water features are provided in **Table 4.4**.

Table 4.4 Water Network and Surface Water Features

Item	Distance/Direction	Details
Ordnance Survey MasterMap Water Network Entries	1m west	Inland river not influenced by normal tidal action (4 records).
	124m west	Lake, loch or reservoir (2 records).
	168m south-west	Inland river not influenced by normal tidal action (2 records).

Item	Distance/Direction	Details
	245m north	Inland river not influenced by normal tidal action (4 records).
Surface Water Features (not represented on mapping)	0m to 248m north, south-east, south, south-west	No further details given (6 records).

4.5 Flooding

Details regarding flooding are provided in **Table 4.5**.

Table 4.5 Flooding

Item	Details
Environment Agency Floodplains	No identified Environment Agency Zone 2 and Zone 3 Floodplains within 250m of the site.
Risk of Flooding from Rivers and the Sea (RoFRaS) Flood Rating	The highest risk of flooding on site is recorded as very low.
Flood Defences	There are no identified flood defences within 250m of the study site.
Areas benefitting from Flood Defences	There are no identified areas benefitting from flood defences within 250m of the site.
Areas benefitting from Flood Storage	There are no areas benefitting from flood storage within 250m of the site.
Groundwater Flooding Susceptibility Areas and Flooding Confidence Areas	The site is within 50m of a BGS flooding susceptible area comprising clearwater flooding of limited potential. The BGS confidence rating in this result is low.

5 Historical Information

A summary of recorded historical features and a review of historical maps are provided below.

5.1 Historical Industrial Sites

Salient information regarding historical industrial sites is provided in **Table 5.1**.

Table 5.1 Records of Historical Potentially Contaminative Uses

Item	Distance/Direction	Use
Potentially Contaminative Uses	15m south	Unspecified pit.
	237m south-west	Cemetery.
Historical Tank Database	-	None recorded.
Historical Energy Features Database	-	None recorded.
Historical Petrol and Fuel Database	-	None recorded.
Historical Garage and Motor Vehicle Repair Database	-	None recorded.
Potentially Infilled Land	2m to 5m south	Pond (4 records).
	4m south-east	Fish Pond (2 records).
	15m south	Unspecified pit.
	237m south-west	Cemetery.

5.2 Historical Mapping

With reference to the GroundSure historical maps, salient information regarding historical land use either on or within 250m of the site is summarised in **Table 5.2**. The GroundSure historical maps are presented in **Appendix 3**.

Table 5.2 Summary of Historical Maps

Map Date	Map Scale	On Site	Off Site
1884 1884 1884-88	1:2,500 1:10,560 1:10,560	The site is within the grounds of Battsford Hall. A series of buildings, probably stables or similar, are within the, roughly, southern half of the site. The remainder is open land.	Battsford Hall and associated buildings are immediately south-west of the site, and an orchard is to the west. Two ponds, including a Fish Pond are south of the site, and a pond is within the orchard to the west. St. Marys Church and Grave Yard are approximately 200m south-west.
1902-03 1903-05	1:2,500 1:10,560	A building has been replaced by a larger, elongate, building on the eastern site boundary.	A building adjacent the site to the west has been removed.
1927* 1928* 1938*	1:2,500 1:10,560 1:10,560	No detail on maps.	No detail on maps.
1953-58	1:10,560	There are no apparent significant changes from the previous edition.	There are no apparent significant changes from the previous edition.
1967 1968 1969*	1:2,500 1:2,500 (2 editions) 1:10,560	There have been minor alterations to the buildings, however, there are no apparent significant changes from the previous edition.	Start Ridge, with Tennis Courts, is east of the site and Hall Cottage is to the south-east. A large depression is immediately west of the Battsford Hall buildings and glasshouses are to the south.

Map Date	Map Scale	On Site	Off Site
1971-76	1:10,000	There are no apparent significant changes from the previous edition.	There are no apparent significant changes from the previous edition.
1995	1:2,500	There are no apparent significant changes from the previous edition.	There are no apparent significant changes from the previous edition.
2002	1:10,000	There are no apparent significant changes from the previous edition.	The layout of buildings adjacent the site to the north-west has changed, however, it is unclear whether several of the buildings have been reduced in size or demolished and replaced.
2010 2014	1:10,000 1:10,000	There are no apparent significant changes from the previous edition.	There are no apparent significant changes from the previous edition.

*Partial map

6 Environmental Information

Records of environmental permits, incidents and registers along with details of landfill or waste sites on or within the vicinity of the site, obtained from public archives via the data supplier GroundSure, are summarised in this section.

6.1 Environmental Permits, Incidents and Registers

Salient information regarding sites holding licences and authorisations, dangerous or hazardous sites, pollution incidents and recorded contaminated land within 250m of the study site is provided in **Table 6.1**.

Table 6.1 Environmental Permits, Incidents and Registers

Item		Distance/Direction	Detail
Industrial Sites Holding Licences and/or Authorisations	Historic IPC Authorisations	-	None recorded.
	Part A(1) and IPPC Authorised Activities	-	None recorded.
	Red List Discharge Consents	-	None recorded.
	List 1 Dangerous Substances Inventory Sites	-	None recorded.
	List 2 Dangerous Substances Inventory Sites	-	None recorded.
	Part A(2) and Part B Activities and Enforcements	-	None recorded.
	Records of Category 3 or 4 Radioactive Substance Authorisations	-	None recorded.
	Licensed Discharge Consents	185m south-west	Effluent type: unspecified. Revocation date 02/06/1997.
		208m south	Effluent type: sewage discharges – final/treated effluent – not water company. Status: new consent, issued 09/03/2007.
	Water Industry Referrals	-	None recorded.
Planning Hazardous Substance Consents and Enforcements	-	None recorded.	
Dangerous or Hazardous Sites		-	None recorded.
Environment Agency Recorded Pollution Incidents	National Incidents Recording System, List 2	-	None recorded.
	National Incidents Recording System, List 1	-	None recorded.
Recorded Part 2A Sites.		-	None recorded.

6.2 Landfill and Other Waste Sites

Details of Environment Agency historical or current landfill sites, BGS/DoE non-operational landfill sites, Local Authority Landfill sites or other waste treatment, transfer or disposal sites within 250m of the site are provided in **Table 6.2**.

Table 6.2 Landfill and Other Waste Sites

Item	Distance/Direction	Detail	
Landfill Sites	Environment Agency Landfills	-	None recorded.
	Environment Agency Historical Landfills	-	None recorded.
	BGS/DoE Non-operational Landfill Sites	-	None recorded.
	Landfills from Local Authority and Historical Mapping Records	-	None recorded.
Other Waste Sites	Waste treatment, transfer or disposal sites	-	None recorded.
	Environment Agency Licensed Waste Sites	-	None recorded.

6.3 Current Land Uses

Records of current potentially contaminative land uses are summarised in **Table 6.3**.

Table 6.3 Potentially Contaminative Land Uses

Item	Distance/Direction	Detail
Potentially Contaminative Industrial Sites	On site	Silo; hoppers and silos (2 records).
Petrol and Fuel Sites	-	None recorded.
Underground Electricity Transmission Cables	-	None recorded.
High Pressure Gas Transmission Pipelines	-	None recorded.

6.4 Designated Environmentally Sensitive Sites

Details of Environmentally Sensitive Sites within 250m of the study site as summarised in **Table 6.4**.

Table 6.4 Environmentally Sensitive Sites

Environmentally Sensitive Site Type	Distance/Direction	Data Source
Nitrate Vulnerable Zone (2 records).	On site	DEFRA

6.5 Railways and Tunnels

Details regarding railways and tunnels on or within 250m of the study site are provided in **Table 6.5**.

Table 6.5 Railways and Tunnels

Feature	Distance/Direction	Use / Detail
Tunnels	-	None recorded.

Feature	Distance/Direction	Use / Detail
Historical Railway and Tunnel Features	-	None recorded.
Historical Railways	-	None recorded.
Active Railways	-	None recorded.
Railway Projects	-	There are no recorded railway projects (High Speed 2 or Crossrail 1) within 250m of the study site.

7 Ground Workings, Mining, Extraction and Cavities

Salient information regarding historical and current surface and underground working features, extraction and natural cavities on or within the vicinity of the site is summarised below.

7.1 Working Features

Details of historical surface ground working features, historical underground working features and current ground working features within 250m of the site are summarised in **Table 7.1**.

Table 7.1 Working Features

Feature	Distance/Direction	Use/Detail
Historical Surface Ground Working Features	2m to 5m south	Pond (4 records).
	4m south-east	Fish pond (2 records).
	15m south	Unspecified pit.
	237m south-west	Cemetery.
Historical Underground Working Features	-	None recorded.
Current Ground Workings	-	None recorded.

7.2 Mining, Extraction and Natural Cavities

Details of mining, extraction and cavities are provided in **Table 7.2**.

Table 7.2 Mining, Extraction and Natural Cavities

Feature	Distance/Direction	Detail
Historical Mining	-	None recorded.
Coal Mining	-	None recorded.
Johnson Poole and Bloomer Records	-	The study site is not located within 1000m of an area when Johnson Poole and Bloomer hold information.
Non-coal Mining	On site	Commodity: Chalk. Sporadic underground mining of restricted extent may have occurred. Potential for difficult ground conditions are unlikely and localised and are at a level where they need not be considered.
Non-coal Mining Cavities	-	None recorded.
Natural Cavities	-	None recorded.
Brine Extraction	-	None recorded.
Gypsum Extraction	-	None recorded.
Tin Mining	-	None recorded.
Clay Mining	-	None recorded.

8 Conceptual Site Model and Risk Assessment

An initial CSM and preliminary assessment of plausible contaminant linkages is presented in this section. It is aimed at identifying possible risks, if any, arising from substances used or deposited on-site, or from other sources of land contamination. Both past and current potentially contaminative land uses have been considered.

8.1 Potential Contaminant Sources

Based on the site walkover and desk study research, the identified potentially contaminative land uses on or within the vicinity of the site are summarised in **Table 8.1**.

Table 8.1 Potential Contaminative Sources

Item	Detail
Summary of Land Use and Potential Contaminative Sources	<u>Historical Site Uses</u> Farmland/farm buildings.
	<u>Current Site Uses</u> Farmland/farm buildings with chemical store, silos, and disused fuel pump.
	<u>Historical Land Use / Features Within Vicinity</u> Unspecified pit, cemetery, potentially infilled land (pond, unspecified pit, cemetery). <u>Current Land Use Within Vicinity</u> Farmland, silos.
Associated Contaminants	Metals, petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), asbestos containing materials (ACMs), ground gas.

8.2 Pathways

For this assessment, the principal potential pathways for contaminant migration are provided in **Table 8.2**.

Table 8.2 Pathways

Source	Pathway
Soil / dust / fibres	Dermal contact, ingestion and inhalation.
Liquid (including surface water / groundwater)	Dermal contact, ingestion, leaching, infiltration, migration.
Harmful ground gases / vapour	Inhalation, accumulation within confined spaces with subsequent asphyxiation or explosion.

8.3 Receptors

Based on the proposals and the findings of the desk study the identified receptors are described in **Table 8.3**.

Table 8.3 Receptors

Receptor	Detail
Site workers	Site workers are anticipated to include those involved with the construction works at the site, particularly ground workers.
End Users	Residents and visitors.
Controlled Waters	Deposits underlying the site are designated Secondary Aquifer (undifferentiated) overlying Principal Aquifer. There is a groundwater abstraction well on site. The site is within Zone 3 SPZ, the nearest surface water feature is on site. The site is at very low risk of flooding.
Flora and fauna	Plants and animals that may be affected by proposed development.
Buildings	The completed buildings including stables converted to dwellings.
Buried services	Potable water pipes are anticipated as part of proposals.

8.4 Preliminary Qualitative Risk Assessment

A CSM illustrating a preliminary assessment of plausible contaminant linkages has been formulated for this site and presented in tabular format in **Appendix 4**. The contaminant linkages have been individually assessed and a summary of the potential geo-environmental risks associated with the site and in the context of the proposed residential development is provided in **Table 8.4**.

Table 8.4 Summary of Preliminary Qualitative Risk Assessment

Issue	Risk Rating	Justification Comments
Contamination Potential		
Potential for significant on-site contamination.	Moderate / low	Identified on site sources include a disused fuel pump and chemical store.
Potential for contaminants to migrate via soil/air/groundwater pathways to site.	Low	Potential off-site sources have been identified, however, the anticipated underlying diamicton deposits will restrict migration on to the site.
Potential for contaminants to migrate via soil/air/groundwater pathways off-site.	Low	Potential on site sources have been identified, however, the anticipated underlying diamicton deposits will restrict migration off site.
Geo-environmental Risk		
Risk of harm to human health based on anticipated conditions.	Moderate / low	Potential sources have been identified associated with chemical and/or fuel spillages/leaks. However, the anticipated ground conditions are expected to restrict the extent and migration of any potential impact.
Risk to site workers.	Moderate / low	Potential sources have been identified associated with chemical and/or fuel spillages/leaks. However, the risk will be mitigated when suitable personal protective equipment and welfare facilities are used.
Risk of pollution to controlled water.	Low	Underlying diamicton deposits are likely to restrict the downward migration of any potential pollutant impact.
Hazards to flora and fauna.	Very low	It is considered unlikely that flora and fauna will be affected.
Hazards to building structures and services – excluding ground gas.	Very low	Low potential of sources of contaminants on site (including pH, sulphates and organics).
Liabilities		
Likelihood of designation as Contaminated Land under Part 2A of EPA 1990.	Low	Some potential for contamination identified - but likely to be addressed under the planning regime.
Liability issues for owner.	Moderate / low	No significant liability issues identified.
Development Implications		
Possible requirement for remediation of soil.	Moderate / low	Soil remediation may be required but is expected to be restricted in extent. Intrusive investigation required to clarify risks.
Possible requirement for remediation of groundwater.	Low	Unlikely that groundwater remediation measures will be required.
Possible requirement for gas protection.	Moderate / low	Potential requirement for ground gas protection measures. Intrusive investigation required to clarify risks.
Special requirements for water supply pipes.	Low	It is considered unlikely that specialist pipework will be required.
Potential limitations on foundation design.	Low	The underlying ground conditions should be taken into consideration during concrete selection.

Issue	Risk Rating	Justification Comments
Risk of encountering materials classed as hazardous waste.	Moderate / low	Localised soil contamination may be present. Intrusive investigation required to clarify risks.

9 Fieldwork and Analysis

The works undertaken as part of the site investigation and subsequent analysis of selected samples is summarised below.

9.1 Site Investigation

The site work undertaken as part of this phase of investigation is detailed in the following section. The site investigation was undertaken in accordance with the scope of works agreed with the client and generally in accordance with industry guidance including BS10175:2011+A2:2017 *Investigations into Potentially Contaminated Sites – Code of Practice* and BS5930: 2015 *Code of Practice for Site Investigations*.

9.1.1 Site work Rationale and Preparatory Works

The investigative positions were selected based on the proposed development, findings of the Phase 1 element of the investigation, and available access. The locations of some exploratory holes were constrained by access restrictions due to overgrown vegetation. The exploratory hole location plan and fieldwork records are presented in **Appendix 5**.

Prior to boring, a cable avoidance tool with signal generator was used to confirm each location was clear of detectable services.

9.1.2 Dynamic Sample Boreholes

A total of six dynamic sample (windowless) boreholes, referenced WS1 to WS5 (including WS1a), were undertaken on 21 June 2018 and were completed at depths between 0.50mbgl to 5.00mbgl. Borehole WS1 was abandoned at 0.50mbgl due to perched water ingress from 0.45mbgl. The sampling equipment comprised of a track-mounted rig used to drive successive 1.00m long, lined core sample barrels into the ground. The diameter of the core barrels ranged from 90mm to 50mm. The recovered plastic core barrel 'liners' were split and sub-sampled on-site by an engineer; the recovered soil samples, taken at regular intervals throughout the length of the boreholes, were placed in laboratory supplied sealed glass jars or plastic containers prior to being stored in cool boxes during transit to the laboratory.

Standard Penetration Tests (SPTs) were undertaken at intervals in all the boreholes to provide data regarding the strength or density of the soil, the result of each test is presented as the 'N' value on the borehole logs, and a hand shear vane was used to give an indication of the shear strength of the cohesive soils encountered.

9.1.3 Standpipe Installations and Monitoring

Single standpipe installations were placed in boreholes WS1a and WS4. Each standpipe comprised 50mm diameter PTFE piping, slotted below 1.00mbgl and installed to a depth of 5.00mbgl. Once introduced into the ground the slotted section was surrounded by suitable gravel pack, above which a sealing material (bentonite) was used. A rubber bung and gas tap were placed at the top of the pipework and a flush cover concreted at surface to protect the installation from damage.

Ground monitoring was undertaken on one occasion on 28 June 2018. Ground gas flow was monitored for a period of up to two minutes; concentrations of ground gases including methane, carbon dioxide, hydrogen sulphide and carbon monoxide were monitored for up to five minutes. The depth to groundwater was measured using a dip-meter. The monitoring results are presented in **Appendix 5**.

9.2 Laboratory Analysis

Details of the laboratory testing of representative samples are given in **Table 9.1** below. The laboratory certificates are presented in **Appendix 6**.

Table 9.1 Summary of Scheduled Contamination Testing

Analysis	No. of Samples Tested	
	Soil	Groundwater
Metals	5	2
Speciated polycyclic aromatic hydrocarbons (PAHs)	5	2
Extractable petroleum hydrocarbons	2	2
Speciated petroleum hydrocarbons	3	-
Benzene, toluene, ethylbenzene, xylene (BTEX) and Methyl tertiary butyl ether (MTBE)	3	-
Volatile and semi-volatile organic compounds (VOCs and SVOCs)	1	-
Total phenols	1	-
Total cyanide	1	-
Asbestos screen	5	-
pH	5	-
Soil organic matter (SOM)	5	-
Total organic carbon (TOC)	-	2
SO ₄ / total sulphate	5	-

10 Ground Conditions

The encountered ground conditions, groundwater and other observations are summarised and discussed below.

10.1 Encountered Ground Conditions

The ground conditions encountered are summarised in **Table 10.1** and discussed below.

Table 10.1 Summary of Encountered Ground Conditions

Stratum	Location	Surface Depth (mbgl)	Base Depth (mbgl)	Proved Thickness (m)
Made Ground	All locations	0.00	0.20 to 0.90	0.20 to 0.90
Lowestoft Formation	All locations	0.20 to 0.90	0.50 to 5.00	>0.20 to >4.80

10.1.1 Made Ground

Made Ground was encountered in all the boreholes. At the locations of WS1, WS1a, WS2 and WS5 reinforced concrete was encountered at the surface to depths between 0.10mbgl and 0.20mbgl. The concrete in WS1 and WS5 was underlain by grey, yellowy grey, orangey brown and greyish brown, locally slightly clayey and sandy, gravel of sub-angular to sub-rounded concrete, flint, and limestone. The concrete in WS1a and WS2 was underlain by soft or firm, yellow brown, greyish brown and orange, slightly sandy, gravelly, clay; the gravel comprised angular to sub-rounded brick, flint, and charcoal. The Made Ground in boreholes WS3 and WS4 comprised brown and grey, slightly sandy gravel of sub-angular to sub-rounded flint. The Made Ground was proven to depths between 0.20mbgl and 0.90mbgl.

10.1.2 Lowestoft Formation

The Lowestoft Formation was encountered in all boreholes below the Made Ground from depths between 0.20mbgl and 0.90mbgl. This stratum initially comprised stiff locally firm, very high strength, orangey-brown, brown, yellowy grey and grey, slightly sandy, slightly gravelly, clay. Below 1.30 to 1.70mbgl in WS1a to WS4 this stratum was grey and had occasional sand pockets. The gravel comprised angular to sub-rounded flint and chalk. The boreholes were completed in this stratum at depths between 0.50mbgl and 5.00mbgl.

10.1.3 Groundwater

Perched groundwater was encountered at a depth of 0.45mbgl at WS1, all other boreholes remained dry during the fieldwork. During monitoring, the groundwater was at depths of 3.16mbgl and 3.20mbgl; however, this is expected to be perched groundwater present within the sand pockets of the Lowestoft Formation.

11 Chemical Laboratory Test Results and Monitoring

The results of chemical laboratory testing and ground gas monitoring are detailed in the following section.

11.1 Soil Analysis

The results of chemical laboratory testing of soil samples for inorganic and organic compounds have initially been compared against the most stringent screening criteria for residential with consumption of home-grown produce end use. The screening criteria hierarchy used is as follows:

- Chartered Institute of Environmental Health (CIEH) and Land Quality Management Ltd (LQM) Suitable for Use Levels (S4ULs).
- Department for Environment Food and Rural Affairs (Defra) Category 4 Screening Levels (C4SLs).
- Contaminated Land: Applications in Real Environments (CL:AIRE) soil generic assessment criteria (GACs).

11.2 Groundwater Analysis

The results of groundwater analysis have been compared to:

- The Water Supply (Water Quality) Regulations 2016 (WSR).
- Guidelines for Drinking-water Quality: World Health Organization (WHO).

11.3 Ground Gas Monitoring

Where applicable the results of ground gas monitoring have been compared to:

- CIRIA 665: Assessing risks posed by hazardous ground gases to buildings.
- BS 8485:2015: Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.

Table 11.1 Results of Laboratory Analysis for Metals

Determinand <i>Metals</i>	Determinand Concentration Range (mg/kg)		Screening Values (mg/kg)				No. of Samples with Elevated Concentrations	Samples with Elevated Concentrations
	<i>Minimum</i>	<i>Maximum</i>	<i>S4Us</i>			<i>C4SLs</i>		
Arsenic	2	13	37			-	0	None elevated
Cadmium	<0.2	<0.2	11			-	0	None elevated
Chromium (III)	6	209	910			-	0	None elevated
Chromium (VI)	<2	<2	6			-	0	None elevated
Copper	<4	13	2,400			-	0	None elevated
Lead	4	26	-			210	0	None elevated
Mercury	<1	<1	40			-	0	None elevated
Nickel	4	19	130			-	0	None elevated
Selenium	<3	<3	250			-	0	None elevated
Zinc	12	91	3,700			-	0	None elevated

Table 11.2 Results of Laboratory Analysis for Polycyclic Aromatic Hydrocarbons

Determinand <i>PAHs</i>	Determinand Concentration Range (mg/kg)		Screening Values (mg/kg)				No. of Samples with Elevated Concentrations	Samples with Elevated Concentrations
	<i>Minimum</i>	<i>Maximum</i>	<i>S4Us</i>			<i>C4SLs</i>		
			<i>1% som</i>	<i>2.5% som</i>	<i>6% som</i>	<i>6% som</i>		
Acenaphthene	<0.10	0.21	210	510	1,100	-	0	None elevated
Acenaphthylene	<0.10	0.19	170	420	920	-	0	None elevated
Anthracene	<0.10	1.59	2,400	5,400	11,000	-	0	None elevated
Benzo[a]anthracene	<0.10	4.87	7.2	11	13	-	0	None elevated
Benzo[a]pyrene	<0.10	3.54	2.2	2.7	3	10	1	WS1a at 0.30m
Benzo[b]fluoranthene	<0.10	4.84	2.6	3.3	3.7	-	1	WS1a at 0.30m

Determinand <i>PAHs</i>	Determinand Concentration Range (mg/kg)		Screening Values (mg/kg)				No. of Samples with Elevated Concentrations	Samples with Elevated Concentrations
	Minimum	Maximum	S4Us			C4SLs		
			1% som	2.5% som	6% som	6% som		
Benzo[ghi]perylene	<0.10	1.46	320	340	350	-	0	None elevated
Benzo[k]fluoranthene	<0.10	1.47	77	93	100	-	0	None elevated
Chrysene	<0.10	4.50	15	22	27	-	0	None elevated
Dibenzo[ah]anthracene	<0.10	0.33	0.24	0.28	0.3	-	1	WS1a at 0.30m
Fluoranthene	<0.10	16.30	280	560	890	-	0	None elevated
Fluorene	<0.10	0.43	170	400	860	-	0	None elevated
Indeno[123-cd]pyrene	<0.10	1.89	27	36	41	-	0	None elevated
Naphthalene	<0.10	0.26	2.3	5.6	13	-	0	None elevated
Phenanthrene	<0.1	5.52	95	220	440	-	0	None elevated
Pyrene	<0.1	13.2	620	1,200	2,000	-	0	None elevated
Total PAH	<1.6	60.2	-	-	-	-	-	-

Table 11.3 Results of Laboratory Analysis for Extractable Petroleum Hydrocarbons

Determinand <i>Petroleum Hydrocarbons</i>	Determinand Concentration Range (mg/kg)		Adopted Screening Value (mg/kg)	No. of Samples with Elevated Concentrations	Samples with Elevated Concentrations
	Minimum	Maximum			
Extractable Petroleum Hydrocarbons	15	129	500	0	None elevated

Table 11.4 Results of Laboratory Analysis for Speciated Petroleum Hydrocarbons

Determinand <i>Petroleum Hydrocarbons</i>	Determinand Concentration Range (mg/kg)		Screening Values (mg/kg)			No. of Samples with Elevated Concentrations	Location of Samples with Elevated Concentrations
	Minimum	Maximum	S4ULs				
			1% som	2.5% som	6% som		
Speciated - Aliphatic							
>C5-C6	<0.01	<0.01	42	78	160	0	None elevated
>C6-C8	<0.05	<0.05	100	230	530	0	None elevated
>C8-C10	<2	<2	27	65	150	0	None elevated
>C10-C12	<2	<2	130	330	760	0	None elevated
>C12-C16	<3	<3	1,100	2,400	4,300	0	None elevated
>C16-C35	<3	<3	65,000	92,000	110,000	0	None elevated
Aliphatic C5-C35	<10	<10	-	-	-	-	-
Speciated - Aromatic							
>C5-7	<0.01	<0.01	70	140	300	0	None elevated
>C7-8	<0.05	<0.05	130	290	660	0	None elevated
>C8-10	<2	<2	34	83	190	0	None elevated
>C10-12	<2	<2	74	180	380	0	None elevated
>C12-16	<2	2	140	330	660	0	None elevated
>C16-21	<3	46	260	540	930	0	None elevated
>C21-35	<10	107	1,100	1,500	1,700	0	None elevated
Aromatic C5-35	<21	155	-	-	-	-	-

Table 11.5 Volatile and Semi-volatile Organic Compounds

Determinand	Determinand Concentration Range (mg/kg)		Screening Values (mg/kg)			No. of Samples with Elevated Concentrations	Location of Samples with Elevated Concentrations
	Minimum	Maximum	S4ULs				
			1% som	2.5% som	6% som		
1,2-Dichloroethane	-	<0.005	0.0071	0.011	0.019	0	None elevated
1,1,1-Trichloroethane	-	<0.005	8.8	18	39	0	None elevated
1,1,2,2-Tetrachloroethane	-	<0.005	1.6	3.4	7.5	0	None elevated
1,1,1,2-Tetrachloroethane	-	<0.005	1.2	2.8	6.4		None elevated
Tetrachloroethene	-	<0.005	0.18	0.39	0.90		None elevated
Tetrachloromethane (carbon tetrachloride)	-	<0.005	0.026	0.056	0.13	0	None elevated
Trichloroethene	-	<0.005	0.016	0.034	0.075	0	None elevated
Trichloromethane (chloroform)	-	<0.005	0.91	1.7	3.4	0	None elevated
Chloroethene (vinyl chloride)	-	<0.005	0.00064	0.00087	0.0014	0	None elevated
Chlorobenzene	-	<0.005	0.46	1.0	2.4	0	None elevated
1,2-Dichlorobenzene	-	<0.005	23	55	130	0	None elevated
1,3-Dichlorobenzene	-	<0.005	0.40	1.0	2.3	0	None elevated
1,4-Dichlorobenzene	-	<0.005	61	150	350	0	None elevated
1,2,4-Trichlorobenzene	-	<0.1	2.6	6.4	15	0	None elevated
Hexachlorobenzene	-	<0.1	1.8	3.3	4.9		None elevated
Phenol	-	<0.1	120	200	380	0	None elevated
Benzene	<0.002	<0.002	0.087	0.17	0.37	0	None elevated
Toluene	<0.005	<0.005	130	290	660	0	None elevated
Ethylbenzene	<0.002	<0.002	47	110	260	0	None elevated

Determinand	Determinand Concentration Range (mg/kg)		Screening Values (mg/kg)			No. of Samples with Elevated Concentrations	Location of Samples with Elevated Concentrations
	Minimum	Maximum	S4ULs				
			1% som	2.5% som	6% som		
o-xylene	<0.002	<0.002	60	14	330	0	None elevated
m-xylene	<0.002	<0.002	59	140	320	0	None elevated
p-xylene	<0.002	<0.002	56	130	310	0	None elevated
MTBE	<0.005	<0.005	49	84	160	0	None elevated

Table 11.6 Asbestos Screening

Determinand	Screening Result	Asbestos Matrix	Asbestos Type	No. of Samples with Asbestos	Location of Samples with Detected Asbestos
Asbestos	Not detected	-	-	-	-

Table 11.7 Groundwater Analysis Results

Determinand	Determinand Concentration Range (ug/l)		Threshold Value (ug/l)		No. of Samples with Elevated Concentrations	Location of Samples with Elevated Concentrations
	Minimum	Maximum	UK DWS			
Arsenic	<5	<5	10	10	0	None elevated
Cadmium	<0.4	<0.4	5	13	0	None elevated
Chromium	<5	<5	50	50	0	None elevated
Chromium (VI)	<20	<20	-	-	-	-
Copper	<5	<5	2000	2000	0	None elevated
Lead	<5	72	10	10	1	WS1a
Mercury	<0.05	<0.05	1	1	0	None elevated
Nickel	<5	7	20	70	0	None elevated

Determinand	Determinand Concentration Range (ug/l)		Threshold Value (ug/l)		No. of Samples with Elevated Concentrations	Location of Samples with Elevated Concentrations
	Minimum	Maximum	UK DWS			
Selenium	6	19	10	10	1	WS4
Zinc	7	16	5,000	3,000	0	None elevated
Benzo(a)pyrene	<0.01	<0.01	-	0.01	0	None elevated
Sum of PAHs (4no. congeners)	<0.01	<0.01	0.1 (sum of 4no. congeners)	0.7	0	None elevated
Total petroleum hydrocarbons	<140 (C5-C35)	<140 (C5-C35)	-	Taste and odour will in most cases be detectable at concentrations below those of health concern, particularly with short-term exposure.	-	No evidence to suggest fuel contamination.

Table 11.8 Summary of Aggressive Ground Analysis

Stratum	Determinand			DS / ACEC Class
	Total sulphate (%)	Water soluble sulphate SO ₄ (mg/l)	pH	
Made Ground	0.22 to 0.42	19 to 29	10.8 to 11.3	DS-1 / AC-1
Lowestoft Formation	<0.02 to 0.06	26 to 41	8.0 to 8.3	DS-1 / AC-1

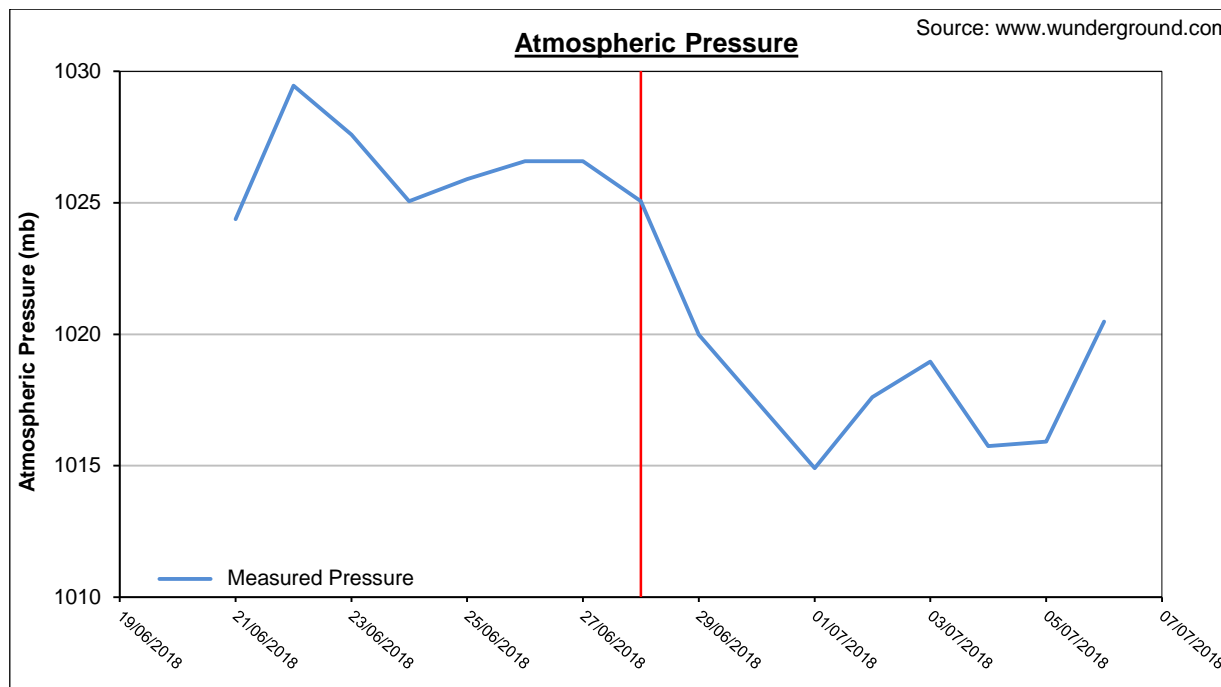
Table 11.9 Summary of Ground Gas Monitoring Results

Date	Location	CO ₂ (%)		CH ₄ (%)		O ₂ (%)		Flow (Max. rate l/hr.)	Atmospheric Pressure (mb)
		Min	Max	Min	Max	Min	Max		
28/06/2018	WS1a	0.2	0.7	0.0	0.0	18.6	20.7	<0.1	1022
	WS4	0.6	1.5	0.1	0.1	19.3	20.5	<0.1	1022

Table 11.10 Workplace Exposure Limits

Substance	Recorded Concentration (ppm)		HSE Workplace Exposure Limits Screening Values (ppm)		Elevated Concentrations
	Min	Max	Long Term	Short Term	
Carbon monoxide	0.0	0.0	30	200	None elevated
Hydrogen sulphide	0.0	0.0	5	10	None elevated
Liquefied Petroleum Gas (VOCs)	0.2	1.0	1000	1250	None elevated

Figure 1 Atmospheric Pressure Chart



11.4 Discussion of Laboratory Analysis Results

The result of chemical laboratory analysis of selected soil samples is discussed in the following section.

11.4.1 Summary of Soil Sample Analysis Results

When compared to the screening values for residential with plant uptake end use, the results of analysis recorded elevated concentrations of PAHs: benzo[a]pyrene, benzo[b]fluoranthene and dibenzo[ah]anthracene in a sample of Made Ground from borehole WS1a at 0.3m depth.

11.4.2 Asbestos

Asbestos was not detected in any of the screened samples.

11.4.3 Groundwater

The analysis of selected groundwater samples recorded elevated concentrations of lead and selenium in the sample from WS1a. The sample was from perched groundwater within the superficial Lowestoft Formation deposits. This perched water is unlikely to migrate laterally or vertically to nearby surface water features or the Principal Aquifer below due to thickness (approximately 18m from historical borehole records) and the relative impermeability of the superficial diamicton deposits. The depth of the groundwater within the Principal Aquifer is also anticipated to be approximately 30mbgl.

11.5 Discussion of Ground Gas Results and Gas Screening Value

The results of ground gas monitoring are summarised below.

11.5.1 Carbon Dioxide and Methane

The monitoring results indicated a maximum carbon dioxide (CO₂) concentration of 1.5% and methane concentration (CH₄) of 0.1%.

11.5.2 Other Gases and Volatiles

Monitoring indicated concentrations of carbon monoxide (CO) and hydrogen sulphide (H₂S) of below detection levels, and volatile organic compounds (VOCs) of 1.0ppm.

11.5.3 Recorded Flow Rate

A maximum flow rate of <0.1l/hr was recorded.

11.5.4 Gas Screening Value and Classification

The recorded maximum concentrations of methane and carbon dioxide have been used to calculate a Gas Screening Value (GSV) for the gassing regime at this site. The GSVs are calculated as worst-case CO₂ or CH₄ concentration / 100 x worst case flow rate, which are provided in **Table 6.8**.

Table 11.11 Gas Screening Values for Carbon Dioxide and Methane

Peak Flow Rate (l/hr)	Worst Case CO ₂ (%)	CO ₂ GSV	Worst Case CH ₄ (%)	CH ₄ GSV
<0.1	1.5	<0.01l/hr CO ₂	<0.1	<0.01l/hr CH ₄

Based on the gas screening value of <0.01l/hr and lack of potential ground gas generation soils encountered, CIRIA C665 Characteristic Situation 1 is considered applicable to the site.

The recorded concentrations carbon monoxide, hydrogen sulphide and liquefied petroleum gas (VOCs) are below the short-term and long-term workplace exposure limits.

12 Updated Qualitative Risk Assessment

The updated assessment of plausible contaminant linkages based on the results of the investigation is presented in **Appendix 7**. The contaminant linkages have been individually assessed and a summary of the potential geo-environmental risks associated with the site and in the context of the proposed development is provided in **Table 7.1**.

Table 12.1 Summary of Updated Qualitative Risk Assessment

Issue	Risk Rating	Justification Comments
Contamination Potential		
Potential for significant on-site contamination.	Moderate / low	Analysis of soil samples has indicated localised elevated concentrations of PAHs in the Made Ground.
Potential for contaminants to migrate via soil/air/groundwater pathways to site.	Low	Potential off-site sources have been identified, however, the anticipated underlying diamicton deposits will restrict migration on to the site.
Potential for contaminants to migrate via soil/air/groundwater pathways off-site.	Low	Potential on site sources have been identified, however, the anticipated underlying diamicton deposits will restrict migration off site.
Geo-environmental Risk		
Risk of harm to human health (end users).	Moderate / low	Analysis has indicated localised contamination. The risk is therefore considered moderate where contamination in the shallow soil has been proved, and low across the remainder of the site.
Risk to site workers.	Moderate / low	Based on the analysis results, the risk is considered moderate to low, however, the risk will mitigated when suitable health and safety measures / PPE are employed.
Risk of pollution to controlled water.	Low	Analysis has recorded an elevated concentration of lead and selenium in a single sample of perched groundwater. This perched water is unlikely to migrate laterally or vertically to nearby surface water features or the Principal Aquifer below due to and the relative impermeability of the superficial diamicton deposits.
Hazards to flora and fauna.	Low	Based on development proposals, encountered ground conditions, and results of analysis.
Hazards to building structures and services – excluding ground gas.	Low	Based on development proposals, encountered ground conditions, and results of analysis.
Liabilities		
Likelihood of designation as Contaminated Land under Part 2A of EPA 1990.	Low	Some potential for contamination identified - but likely to be addressed under the planning regime.
Liability issues for owner.	Low	No significant liability issues identified.
Development Implications		
Possible requirement for remediation of soil.	Moderate	Minor remedial works likely to be required. Provisionally assume some removal of contamination from hot-spots and nominal cover system.
Possible requirement for remediation of groundwater.	Low	No groundwater remediation likely to be required.
Possible requirement for gas protection.	Low	No special precautions required based on ground investigation findings.
Special requirements for water supply pipes.	Low	Pipes may be directed through affected soil; however, specialist pipework may not be required.
Potential limitations on foundation design.	Low	Based on encountered ground conditions and results of analysis.

Issue	Risk Rating	Justification Comments
Risk of encountering materials classed as hazardous waste.	Moderate / low	Based on the analysis results and encountered ground conditions.

13 Contamination Conclusion and Recommendations

The following recommendations are based on the results of the conceptual site model and risk assessment.

13.1 Summary of Development Proposals and Ground Investigation Results

The proposals, the encountered ground conditions and analysis results are summarised below.

13.1.1 Development Proposals

The development proposals include the conversion of four barns to create five dwellings with private gardens and amenity space.

13.1.2 Summary of Encountered Ground Conditions and Groundwater

The encountered ground conditions comprised Made Ground to depths between 0.20mbgl and 0.90mbgl underlain by the Lowestoft Formation to depths of at least 5.00mbgl. Perched groundwater was encountered at a single location, the remaining boreholes were dry. During subsequent monitoring the perched groundwater was at depths of 3.16mbgl and 3.20mbgl.

13.1.3 Summary of Analysis and Screening Results

When compared to the screening values for residential with plant uptake end use, the results of analysis recorded elevated concentrations of PAHs: benzo[a]pyrene, benzo[b]fluoranthene and dibenzo[ah]anthracene in a sample of Made Ground from borehole WS1a.

The analysis of selected groundwater samples recorded elevated concentrations of lead and selenium in the sample from WS1a. However, the sample was perched groundwater which is unlikely to migrate laterally or vertically to nearby surface water features or the Principal Aquifer below due to and the relative impermeability and anticipated thickness of the superficial diamicton deposits.

Based on the gas screening value of <0.01l/hr and encountered ground conditions CIRIA C665 Characteristic Situation 1 is considered applicable to the site.

13.2 Conclusion

Based on the conceptual site model and risk assessment, risk to end users and site workers has been identified from PAH within the proposed soft landscaping areas around WS1a.

13.3 Recommendations

Recommendations are provided below.

13.3.1 Remediation / Mitigation Measures

Remediation and mitigation measures for ground workers and end users are provided below.

Protection of Ground Workers

The risk to ground workers due to contaminant impacted soil will be mitigated upon implementation of on-site health and safety measures following risk assessment. This should include the provision and use of welfare facilities and suitable protective measures.

Protection of End Users

Analysis has indicated the Made Ground at the locations of WS1a at 0.3m depth, located adjacent the building referenced 'The Old Mill', is impacted with PAHs above. Remediation

of the proposed gardens to the west and south of this building will therefore be required.

It is recommended that a supplementary investigation is completed to confirm the extent of the affected soil, possibly reducing the quantity of soil remediation required. It is also recommended that additional testing is completed within areas of the site that were previously inaccessible, following site clearance. Remediation is considered unnecessary where buildings and hardstanding are proposed as they will provide a pathway break and remove risk.

Prior to groundworks commencing, a Remediation Strategy (RS) should be produced detailing the remediation to be completed. The outline soil remediation will consist of the removal of the contamination impacted Made Ground to a depth of 0.60mbgl or until the natural undisturbed soil is encountered, whichever is shallower, followed by its replacement with imported, certified clean, soil. An alternative option would be the revision of the development proposals to incorporate hardstanding across areas of PAH-impacted soil to provide a pathway break between end users and the affected soil. The method of remediation should be discussed and agreed with the Local Authority in advance of groundworks.

13.3.2 Buried Services

Potable water pipework shall comply with the Water Supply Regulations; the agreement of the water provider and Local Authority should also be sought regarding the potable water pipework and fittings selected prior to commencement.

13.3.3 Watching Brief

It is recommended that a watching brief be maintained on site, particularly during the groundwork stage. During any ground works an appraisal of the exposed soils should be made by a competent person, this as an example could be the site manager. If any material is noted to show visual and/or olfactory signs of contamination it should be stockpiled separately and tested prior to its appropriate removal off-site or re-use. If soils suspected of being contaminated are encountered, it is recommended that a contaminated land specialist is consulted.

13.3.4 Importing and Re-Use of Soil and Materials Management Plan

Excavated soil that is to remain and be re-used on site, assuming it is suitable for the proposed use, may not be determined as waste and its re-use therefore may not require an Environmental Permit. It may be necessary to consult the Environment Agency or other statutory bodies regarding re-use of soils as part of the proposals and whether a Materials Management Plan or Environmental Permit is required. In any case, a site waste management plan or materials management plan may assist the design and cost assessment of the proposed development. This should be devised within the design phase of the scheme.

13.3.5 Soil Disposal

The client and contractors are advised to follow the process outlined in the Environment Agency's Technical Guidance Document WM3 '*Waste Classification – Guidance on the Classification and Assessment of Waste*', 1st edition 2015. Background information and the results of chemical laboratory analysis within this assessment may be used as part of an initial characterisation to determine the likely waste classification of waste soils.

13.3.6 Statutory Authority Consultation

It is recommended that this report be sent to the statutory authorities including the Local Authority Environmental Health and Planning Departments prior to site works commencing to seek their comments. Where necessary, they will consult the Environment Agency or other relevant statutory authorities. If applicable to this project, this report should also be provided to the relevant building warranty provider.

14 Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the research carried out. The results of the research should be viewed in the context of the work that has been carried out and no liability can be accepted for matters outside the stated scope of the research. Any comments made on the basis of information obtained from third parties are given in good faith on the assumption that the information is accurate. No independent validation of third party information has been made by agb Environmental Ltd.

Should any changes to the development be proposed, including changes to the proposed landscaping, then the risks will need to be reassessed. This may require additional site investigation work and may result in the need for alteration of the remedial works.

Advice provided within this report is based on current guidelines available at the time of writing. This report is subject to amendment in light of additional information becoming available or statutory consultee review, including the Environment Agency and Local Authority and the NHBC.

It is possible the conditions observed during the site investigation may change. This may result in changes to sources, pathways or receptors that were unforeseen and unexpected. Statements relating to ground gas or groundwater conditions are based on observations made at the time of the site investigation (unless otherwise stated). Ground gas or groundwater conditions may vary as a result of seasonal fluctuations or other effects.

Ground contamination can exist as small discrete areas of contamination and there can be no certainty that any or all such areas have been sampled or identified. This is particularly significant for an investigation by exploratory holes (as used in this site investigation) as a relatively small sample of soil is extracted, which may not be entirely representative of the surrounding ground conditions.

The geotechnical advice given in this report seeks to provide foundation design guidelines for the proposed building(s). The recommendations/advice given is based on the available information obtained during the investigation. Should any unusual ground conditions be encountered that differ from those proved in the exploratory holes further advice should be sought from agb Environmental Ltd.

This report is written in the context of an agreed scope of work between agb Environmental Ltd and the Client and should only be used in this specific context. Re-interpretation of the Site Investigation and/or this report in whole or part may become necessary if additional information becomes available or practices or legislation changes. agb Environmental Ltd does not provide legal advice; the advice of the Client's legal advisors may also be required. agb Environmental Ltd Terms and Conditions apply.