Wressle Wellsite, Scunthorpe

Ground Investigation Report
For Egdon Resource UK Limited

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Document Details:

Date: March 2018
Reference: JW0648-OIC-XX-XX-RP-V-R001
Status: Draft

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Executive Summary

(Wressle Wellsite, Scunthorpe)

Location:	*The site is located approximately 1.5km north of the village of Wressle and is situated within the land associated with The Sadlers Lodge Farm. The site can be accessed from Brigg Road (B1208), utilising a farm track situated to the south of the building associated with The Sadlers Lodge Farm.*
History:	*A brief summary of historical ordnance survey maps, from 1886 to 2018 is presented below:* ***On-site:*** *1886 – 2017* *The site is an open field.* ***Off-site:*** *1886 – Present* *The site is surrounded by numerous drainage ditches and surface water features, the nearest of which is Ellas Beck which bounds the site both on the western and northern boundary.* *The site is predominantly surrounded by open fields and woodland.*
Geology& Hydrology:	***Geology*** *Superficial – Sutton Sand Formation* *Bedrock – Kellaways Clay Member* *Kellaway Sand Member* *Cornbrash Formation* *Rutland Formation, Blisworth Limestone Formation and Blisworth Clay Formation* *Faults – Three faults were noted to be within 1000m of the site.* ***Groundwater*** *Sutton Sand Formation & Cornbrash Formation – Secondary A Aquifers* *Rutland Formation, Blisworth Limestone Formation and Blisworth Clay Formation – Secondary B Aquifers*
Environmental Considerations:	*A SSSI is located approximately 600m to the west of the site.* *A source protection zone borehole is situated approximately 80m north-east of the site.*
Mineral Extraction:	*According to the Coal Authority, the site is not situated within an area that is affected by coal mining.* *One BGS recorded mineral site is present 700m to the west of the site, associated with an opencast limestone extraction, operations have now ceased.*
Ground conditions:	*The ground conditions are typified by the presence of made ground / topsoil typically underlain by variable orange, brown and grey sands (Sutton Sand Formation). This strata is typically underlain by clays of the Kellaways Clay Member.*
Contamination Summary:	*Seven exceedances of HH GAC were noted onsite within the made ground only. No exceedances were recorded within the natural strata at the site.*
Further Works:	*Consider herbicides and pesticide testing of the natural strata to provide a baseline assessment.* *Undertake in-situ plate load testing if further CBR testing is required.* *Post completion assessment of the ground conditions on removal of the wellsite.*

Limitations

This report describes a geo-environmental investigation, carried out on behalf of Egdon Resource UK Limited, on site at Wressle, Scunthorpe.

This investigation has been carried out to assess the shallow ground condition of the site.

This report is a retrospective baseline report for the wellsite. It will specifically review the historical details of the site, prior to the construction of the wellsite and provide a baseline ground condition report. Therefore, the preliminary conceptual assessment will not consider the implications of hydrocarbon production that is currently onsite. However, the contamination summary will make reference to any potential contamination that may have arisen as a result of the current site use.

This report has been produced on behalf of the Client (Egdon Resource UK Limited), and no responsibility is accepted to any Third Party for all or any part. This report should not be relied upon or transferred to any other parties without the express written authorisation of Opus International Consultants (UK) Limited. If any unauthorised Third Party comes into possession of this report, they rely on it at their own risk and the authors owe them no duty of care or skill.

Findings and opinions conveyed via the desk study within this report are based on information obtained from a variety of sources as detailed within this report, which Opus believes are reliable. Nevertheless, Opus cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

The comments on groundwater and ground gas conditions are based on observations made at the time of the investigation. It should be noted, however, that groundwater and ground gas levels may vary from those reported due to seasonal or other effects.

Whilst this report may express an opinion on the possible configuration of strata, contaminants or gases between or beyond exploratory hole positions or on the possible presence of features based on either visual, verbal or published evidence, this is for guidance only, and no liability can be accepted for its accuracy.

Existing manhole covers were not lifted and drainage runs were not inspected during the course of this ground investigation.

The site plans enclosed in this report should not be scaled from.

1. Introduction

1.1. General

Opus has been commissioned by the client to undertake a shallow depth Geo-Environmental Investigation of the current wellsite in Wressle, Scunthorpe.

1.2. Background

The site currently comprises a well abstraction point, a bunded area to facilitate storage tanks and associated hard standing.

1.3. Objectives

The objectives of this study are to:

- Undertake a detailed desk study;
- A preliminary Conceptual Site Model;
- Provide an intrusive assessment of the ground conditions underlying the site, in addition to the related geotechnical properties and any associated potential constraints, and;
- Assess the current environmental parameters of the site.

1.4. Scope

The following tasks have been completed in undertaking this geo-environmental investigation:

- A review of the historical maps, to determine previous land use that may have impacted the site and surrounding area;
- A review of the published geological/hydrogeological data for the site to determine the anticipated strata and environmental sensitivities;
- Obtain and review an Envirocheck Report to identify potential environmental issues at the site and/or in the surrounding area,
- A detailed intrusive investigation with associated environmental and geotechnical in-situ and laboratory testing;
- The assessment and evaluation of any potential risks to human and controlled water, and;
- The assessment of the underlying ground conditions on-site.

2. The Site

2.1. Site Description

The site is located approximately 1.5km north of the village of Wressle and is situated within the land associated with The Sadlers Lodge Farm. The site can be accessed from Brigg Road (B1208), utilising a farm track situated to the south of the building associated with The Sadlers Lodge Farm.

The site is rectangular in shape and approximately 0.83Ha in plan area and centred on approximate Ordnance Survey Grid Reference 496823,411125 as displayed on drawing ref. JW0648-OIC-ZZ-XX-DR-V-0001_S0_P01, site location plan.

2.2. Site Layout and Surrounding Land Use

The site is currently used as a wellsite and comprises an area of hardstanding surrounded centrally by a rectangular drainage ditch, and in turn mounded material located along the northern and western site boundaries. Given that this report is retrospective, a site walkover prior to the current land use has not been undertaken.

The surrounding land use comprises open field and woodlands associated with The Sadlers Lodge Farm.

The site is bound in the north by Ella Beck.

3. Desk Study

3.1. Sources of Information

An area extending approximately 1000m from the site boundary has been considered for the purposes of this assessment as shown on Landmark Envirocheck Report (Ref: 160118883_1_1 dated 21st March 2018).

The sources of information utilised to obtain geotechnical, historical and environmental information relating to the development are presented in Table 3.1 sources of information.

Types of Information	Sources	Details
Historical Maps	Envirocheck	Historical Mapping
Geological	British Geological Survey (BGS) Envirocheck	BGS online databases (http://www.bgs.ac.uk/) Envirocheck (Mapping)
Mining and Quarrying	Envirocheck Report	Envirocheck (data sheet and mapping)
Hydrogeology	Envirocheck	Envirocheck (data sheet and mapping) Interactive Map (Website)
Hydrology	Envirocheck Environment Agency	Envirocheck (data sheet and mapping) BGS online databases (Website) Interactive Map (Website)
Environment	Envirocheck	Envirocheck (data sheet and mapping) Interactive Map (Website)
Topographical	Ordnance Survey Mapping Google Earth	Promap (http://www.promap.co.uk) Google Earth

3.2. Site History

Opus has reviewed historical maps recorded over selected periods to identify key historical land uses and the historical development of the site and surrounding area. The inspected historical maps were provided as part of the Landmark Envirocheck Report (Ref: 160118883_1_1 dated 21st March 2018) and are included within the Envirocheck Report within Appendix A. The reviewed historical maps date from 1886 to 2018.

The current land use has not been taken into consideration as part of this historical review.

Table 3.2 and 3.3 below summarise the pertinent historical development of the site and surrounding area based upon the inspected maps.

Table 3.2 On-site Historical Review

Historical Feature	Area of Site	Mapped Dates
Open Fields	Whole Site. A field boundary is shown to intersect the sites south-west corner. 1994 - The field is shown as a section of a larger field. 1999 – The north-east corner of the site appears to be used for storage of hay bales.	1886 - 2017

Table 3.3 Off-site Historical Review

Historical Feature	Distance/Direction from site	Mapped Dates
Ella Beck	Located approximately 80m to the west of the site and immediately bounding the site in the north. Ella Beck is orientated approximately north to south along the western site boundary and then shifts in orientation south-west to north-east where if meets the farm track associated with Appleby Lodge Farm	1886 - Present
Open fields	The site forms part of a larger field network and is bound on all sides by open field. 1907 – The arrangement of the field network demonstrates change.	1886 - Present
Appleby Lodge Farm	The buildings associated with Appleby Lodge farm are location approximately 450m to the west of the site. A farm access track is orientated south-west to north-east extending from the farm buildings along the northern boundary of the site.	1886 - Present
Rowland Plantation / Far Wood / East Wood	Woodland identified as Rowland Plantation, Far Wood and East Wood extends from the north of the site westward through to the south of the site, approximately 300m away from the site at the closest point. 1940 – The wood to the west of the site are now shown approximately 150m west of the site.	1886 - Present
Quarry	Located approximately 700m west of the site.	1886 - 1972
Western Drain	Located approximately 320m east of the site, a surface water drain identified as Western Drain is orientated south-east to north-west.	1886 - Present
Ponds / Reservoir	Approximately 770m south of the site. 1907 – Identified as a reservoir.	1886 - Present
	950m south of the site.	1886 - Present
	Approximately 980m south of the site.	1886 - Present
	Approximately 890m south east of the site.	1886 - 1967
Water Feature	A square water feature located approximately 700m north-east of the site.	1886 - 1908
Brigg Road (B1208)	Located approximately 550m west of the site.	1886 - Present
Wells	Two wells located approximately 280m and 350m north-west of the site respectively.	1887 – 1908
	Two wells located approximately 500m west of the site associated with Appleby Lodge Farm.	1887 – 1908
	One well approximately 80m north-west of the site.	1908 – 1967
	A well is identified 800m south of the site.	1908 – 1967
	A well is show approximately 500m south-east of the site associated with Broughton Decoy House.	1908 – 1967

Sir Rowlands Winn's Drain	Located approximately 570m north-east of the site, a surface water drain identified as Sir Rowlands Winn's Drain is orientated south-east to north-west.	1907 – Present
Drains	Various drains located approximately 50m west of the site.	1967 – Present
Woods	Various wooded areas are now shown within 1km of the site. the closest of which is located approximately 500m east of the site.	1956 – Present
Clapgate Pumphouse	Located approximately 270m north-east of the site.	1999 – Present
Farm Buildings	Located approximately 150m north-east of the site.	1999 – Present

3.3. Topography

The site is generally level and resides at approximately 10 meters above Ordnance Datum (m AOD). With the exception of the material mound which bounds the site to the north and west.

3.4. Geology

According to a review of the geological plans contained within the Envirocheck Report and readily available BGS information, the anticipated geology is expected to comprise that shown in Table 3.4 below.

Table 3.4 Anticipated Geology

Anticipated Strata	**Description**	Anticipated Thickness (m)
Made Ground	Considering the current site use, it would be prudent to assume a limited amount of made ground on site as a result of the creation of the wellsite.	Limited thickness anticipated less than 1m below existing ground level (begl).
Sutton Sand Formation	Superficial deposits formed in the quaternary period through a predominantly wind-blown environment.	To depth of approximately 5.0m begl.
Kellaways Clay Member - Mudstone	Sedimentary bedrock formed in the Jurassic period, through an environment previously dominated by shallow seas described as mudstone with thin beds of siltstone and sandstone with modules of argillaceous limestone.	Anticipated between approximately 5.0m to 10.0m begl.
Kellaways Sand Member	Silicate sandstone and silicate siltstone, calcareous cemented with interbeds of sandy and silty mudstone.	Anticipated between approximately 5.0m to 10.0m begl.
Cornbrash Formation - Limestone	Sedimentary bedrock formed in the Jurassic period, through an environment previously dominated by shallow carbonate seas described as limestone predominantly bioplastic wackestone and packestone.	Anticipated between approximately 10m to 12.0m begl.
Rutland Formation, Blisworth Limestone Formation and Blisworth Clay Formation (Undifferentiated)	Interbedded argrillaceous rock and Limestone. Sedimentary bedrock formed in the Jurassic period, through an environment previously dominated by shallow carbonate seas.	Anticipated between approximately 12.0m to 25.0m begl.

The BGS website indicates that there are five historical borehole records available for review located with the area of the site. These records are summarised in Table 3.5.

Table 3.5 Borehole Records

Borehole Name	Date	Location	Description
SE91SE140	February 2017	South-west corner of the site.	- 0.0m – 5.3m Superficial Deposits / Weather Bedrock - 5.3m – 6.0m Kellaways Formation
SE91SE141	February 2017	South-east corner of the site.	- 0.0m – 5.0m Superficial Deposits / Weather Bedrock - 5.0m – 6.0m Kellaways Formation
SE91SE142	February 2017	North-east corner of the site.	- 0.0m – 5.0m Superficial Deposits / Weather Bedrock - 5.0m – 6.0m Kellaways Formation
SE91SE143	February 2017	North-east corner of the site.	- 0.0m – 10.0m Superficial Deposits / Kellways Formation - 10.0m – 12.0m Combrash Formation - 12.0m – 25.0m Blisworth Clay, Blisworth Limestone and Rutland Formations - 25.0m – 48.0m Lincolnshire Limestone Formation - 48.0m – 50.0m Grantham Formation
SE91SE9	July 1918	North-west corner of the site.	- 0.0m – 0.30m Topsoil - 0.30m – 0.60m Ironstone - 0.60m – 2.0m Sand - 2.0m – 2.70m Peat - 2.70m – 5.80m Clay and Gravel (interbedded) - 5.80m – 25.0m Clays and Limestone

3.5. Faults

Three fault are note within 1000m of the site located approximately 300m and 800m north-east of the site respectively and 650m south-west of the site. All of the faults are orientated approximately north-west to south-east.

3.6. Mining Activity and Quarrying

The site is not located within a Coal Authority Reporting area and is not deemed to be affected by coal mining. There is no historical evidence to suggest that mining has occurred on site

The Envirocheck Report indicates that there is a BGS Recorded Mineral Site one opencast mineral quarry located approximately 700m to the south west of the site as identified on the historical maps. The site was noted to extract limestone, however has now ceased operation.

3.7. Ground Stability

The following ground stability hazard information presented in Table 3.7 has been obtained from the Envirocheck Report.

Table 3.7 Ground Stability Hazards

Hazard	Hazard Rating
Collapsible Ground	No Hazard
Compressible Ground	No Hazard
Ground Dissolution	Very Low
Landslides	Very Low
Running Sands	Low
Shrink/Swell Clay	Moderate

3.8. Hydrogeology

The Environment Agency (EA) classifies the underlying superficial Sutton Sand Formation (SSF) deposits and also the underlying bedrock of the Cornbrash Formation (CBF) as a Secondary A aquifers. These are typically described as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

According to the EA, the bedrock of the Rutland Formation, Blisworth Limestone Formation and Blisworth Clay Formation are designated as Secondary B aquifers. These are predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.

The site is not shown to be within any Groundwater Source Protection Zones. A source protection zone borehole is situated approximately 80m north-east of the site, however the site does not fall within the associated zone of protection.

The site is however shown to be situated within a medium-high groundwater vulnerability zone.

Thirty three groundwater abstraction licences were noted within a 500m of the site. The nearest relates to industrial processing undertaken by the British Steel Corporation and noted approximately 300m north-east of the site and associated with the West Drain.

3.9. Hydrology

The nearest surface water feature is Ella Beck which immediately bounds the site along the northern site boundary. However, numerous further surface water features are noted within 500m of the site boundary.

The site is indicated to be located within an EA indicative flood plain. This is identified by the EA as being Flood Zone 1. However, this report should not be regarded as a flood risk assessment.

The Envirocheck Report notes that the site is located within an area with potential for groundwater flooding to occur at surface.

3.10. Radon

According to the Building Research Establishment (BRE) Report BR211 entitled ‘Radon: Guidance on protective measures for new buildings’, 2015, and the Envirocheck Report the site is located within a lower probability radon affected area where less than 1% of homes are estimated to be at or above the Action Level.

As a result no radon protective measures are considered necessary as part of any developments at this site.

3.11. Designated Sensitive Sites

The site is identified as being located within a nitrate vulnerable zone.

The site does not lie within an environmentally sensitive areas, nature reserves, Sites of Special Scientific Interest (SSSI) or special conservation, however a SSSI (Broughton Far Wood) is located approximately 600m to the west of the site and Ancient Woodland (Far Wood) is located at approximately 750m to the west.

4. Regulatory Database Searches

4.1. Introduction

Opus commissioned a Landmark Envirocheck database search of available regulatory agency records to evaluate whether activities on or near the subject site have the potential to create a significant impact on the future use of the site. The reviewed databases are compiled by national and local governmental agencies. The database search essentially relates to operational activities for which licences or authorisations are required and have been obtained pursuant to environmental laws. It is therefore possible that there are unauthorised activities being carried out in the vicinity of the subject site that are not detailed. It is noted that the database is not updated regularly and more recent unlisted or otherwise unregistered activities may therefore be present in the surrounding area.

Sites identified within the study radius are evaluated to assess if they are likely to have had an adverse impact on the subject development or could be adversely affected by the subject development. The criteria used to evaluate sites within the study radius include distance from the subject development, expected depth and direction of groundwater and surface water flow, likely storm water flow direction, and presence/absence of documented contaminant releases at the identified sites.

The approximate distances to features described in this section have been estimated from the closest site boundary and may also be subject to an error of up to 10m.

4.2. Database Review

The information below has been summarised from the Landmark Envirocheck Report enclosed in Appendix A. The Landmark Envirocheck report comprises a database of information obtained from a variety of sources including the EA and the BGS amongst others. The salient issues which relate to the site are summarised as follows unless covered in previous sections of this report:

- There are is one registered mineral extraction point noted within 1km of the site which has now ceased operation.
- There are no recorded landfills within 1km of the site.
- There are no recorded Licensed Waste Management Facilities within 500m of the site.
- There are no Local Authority Pollution and Prevention and Controls within 500m of the site.
- There are no licensed discharge consents within 500m of the site.
- There are no water abstractions within 250m of the site.
- There has been no recorded Pollution Incidents to Controlled Waters within 500m of the.
- There are no Control of Major Accident Hazard (COMAH) sites within 500m of the site.
- There is one area of potentially infilled land (non-water) located at approximately 700m to the west of the site.
- There is one recorded trade directory entry located within 500m of the site. This relates to swimming pool repairs and servicing, however is no longer active.
- A single tank is noted to be situated approximately 50m from the site. (This was not identified throughout the historical map review and no further information is provided).
- There are no fuel station entries recorded within 500m of the site.

4.3. Summary

There are no recorded former activities considered likely to be significant in the context of the site. No activities or incidents were identified from the database search that are considered likely to have resulted in a potential contamination source that may impact or may have historically impacted the soil and/or groundwater conditions at the subject site prior to the current land use.

5. Preliminary Conceptual Site Model

5.1. Introduction

This section presents an appraisal of the desk study findings based upon current legislation in order to identify potential risks and contamination issues associated with the site and therefore develop a preliminary conceptual site model (PCSM).

Current best practice recommends that the determination of hazards due to contaminated land is based on the principle of risk assessment, as outlined in Part IIA of the Environmental Protection Act 1990 and detailed within the DEFRA document CLR11, which outlines the framework for the management of contamination. For a risk to be present, there must be a viable pollutant linkage i.e. a mechanism whereby a source impacts upon a receptor via a pathway. A source, pathway and receptor are defined as:

- **Source:** A substance that is in, on or under the land and has the potential to cause harm or cause pollution to the surrounding environment.
- **Pathway:** A route or means by which a receptor can or could potentially be exposed to, or affected by, a contaminant.
- **Receptor:** A living organism, a group of living organisms, controlled waters, an ecological system or piece of property, which is being, or could be, harmed by a contaminant.

Each of these elements can exist independently of one another, but they create a potential risk only where they are linked together, so that a particular contaminant affects a particular receptor through a particular pathway. If all three are identified in this manner, then a 'pollutant linkage' potentially exists.

Using criteria broadly based on those presented in CIRIA Report "Contaminated Land Risk Assessment: A Guide to Good Practice" (CIRIA Report C552), the magnitude of the risk associated with potential pollutant linkages has then been assessed.

It should be noted that this preliminary conceptual site model to not consider the implications or impact of the current site use.

5.2. Potential Sources

Based upon the available information, the following are considered potential sources of contamination:

- Pesticides and herbicides associated with the historical land use as farmland.

5.3. Potential Pathways

Based upon the available information, the following are considered potential pathways:

- Inhalation of dust/vapours;
- Ingestion;
- Dermal contact;
- Vertical migration through unsaturated zone (including leaching of contaminants);
- Lateral migration within saturated zone;
- Uptake by vegetation;
- Gas/vapour migration through unsaturated zone, and;
- Aggressive attack.

5.4. Potential Receptors

Based upon the available information, the following are considered potential receptors:

- Future site users;
- Off-site users;
- Nearby land drains and wells including Ella Beck;
- Groundwater – underlying Secondary A Aquifer (Sutton Sand Formation & Cornbrash Formation) and Secondary B Aquifer (Rutland Formation, Blisworth Limestone formation and Blisworth Clay Formation), and;
- Building materials.

5.5. PCS Summary

Table 7.1 identifies the viable pollutant linkages that have been identified in the context of the site end users and the associated potential risks.

Table 7.1 Preliminary CSM and Risk Assessment

Potential Source	Potential Pathway	Potential Receptor	Probability	Severity	Risk Rating	Comments
Pesticides and herbicides associated with historical land use as farmland.	Inhalation, ingestion, dermal contact	Future site users	Likely	Minor	Low	Presence of significant contamination deemed unlikely. Chemical testing recommended to determine risks posed.
	Inhalation, ingestion, dermal contact	Construction workers	Likely	Minor	Low	Appropriate usage of PPE and work practices can mitigate potential risks during construction phase. Chemical testing recommended to determine risks posed.
	Vertical migration through unsaturated zone (including leaching of contaminants)	Underlying Secondary A Aquifer	Unlikely	Medium	Low	Chemical testing recommended to determine risks posed.
	Lateral migration (including leaching of contaminants)	Surface water features and abstraction points	Unlikely	Medium	Low	Nearest surface water Ella Beck and source protection zone borehole. Chemical testing recommended to determine risks posed.
	Aggressive attack	Building materials	Unlikely	Mild	Low	Testing required to determine required concrete grade.

6. Ground Investigation Methodology

6.1. Objectives

The objectives of the investigation were to address the following;

- Assess the ground conditions (and geotechnical properties) underlying the site;
- Assess the potential presence and significance of any contamination that may be present, and;
- Assess the potential risks to human health and controlled water receptors.

6.2. Clearance of Underground Services

As the site had recently been developed as a wellsite, all service locations were known and were identified by an engineer on the day of the site investigation and therefore additional site clearance was not undertaken by Opus.

6.3. Site Works

A site investigation was undertaken on the 23rd February 2018 and comprised:

- Six windowless sample boreholes (WS01 – WS06) progressed to depths between 4.00m to 5.50m begl, undertaken by RP Drilling Ltd utilising a percussive windowless sampling rig (Competitor Dart).
- Six Transport Research Laboratory (TRL) Dynamic Cone Penetrometer (DCP) test locations (WS01 TRL – WS06 TRL) progress to depth between 860mm and 950mm from existing ground level.

All works were undertaken under the supervision of an Opus field engineer.

Disturbed samples were taken at selected intervals from the strata encountered, placed in laboratory supplied containers and submitted for chemical testing.

In-situ standard penetration tests (SPTs) were undertaken at selected depths within all windowless boreholes.

All windowless sample boreholes were progressed to a depth of SPT refusal (N value = 50).

The site had previously been made up with compact stone overlying a geotextile membrane. As such all borehole positions with the exception of WS01 were cleared of the near surface made ground utilising a machine excavator and the underlying membrane was removed by a Zetland engineer. Upon completion boreholes were backfilled with arisings, and the membrane was then repaired by a Zetland engineer prior to the replacement of the compact stone.

The encountered geology was logged by an Opus field engineer, in accordance with BS EN ISO 14688. Any visual or olfactory evidence of potential contamination was also recorded.

The approximate locations of the exploratory holes are shown on Drawing DO JW0648-OIC-ZZ-XX-DR-V-0002_S0_P01Exploratory Hole Location Plan and the exploratory hole logs are presented in Appendix B.

6.4. Chemical Testing

As part of the assessment for potential contamination at the site, samples were subjected to selected chemical analysis. This analysis was undertaken by i2 Analytical Ltd, a UKAS and MCERTS accredited laboratory.

The following soil analyses were undertaken:

- Inorganic Heavy Metals 6 samples
- Polycyclic Aromatic Hydrocarbons (PAH's) 12 samples
- Total Petroleum Hydrocarbons (TPH-CWG) 12 samples
- Total Organic Carbon (TOC) 12 samples
- Asbestos ID 6 samples
- pH and Sulphate 3 samples

Results of the chemical testing are presented in Appendix C.

6.5. Geotechnical Testing

Geotechnical laboratory testing was not required as part of this investigation.

6.6. Gas Monitoring

Gas monitoring was not required as part of this investigation.

6.7. Groundwater Monitoring

Groundwater monitoring was not required as part of this investigation.

6.8. Asbestos

No asbestos containing materials were observed on site during the site investigation.

7. Result of the Investigation

7.1. Strata Encountered

A desk based appraisal of the anticipated geology based upon a review of British Geological Survey (BGS) information was reviewed prior to undertaking the site investigation. In summary, this identified Sutton Sand Formation (to approximately 5m depth), underlain by the Kellaways Clay Member (to approximately 10m depth) and subsequently underlain by the Cornbrash Formation, and the Rutland Formation/Blisworth Limestone Formation/Blisworth Clay Formation respectively. In addition to this, a limited thickness (approximately 1m) of made ground was anticipated from ground level due to the development of the wellsite. The intrusive works generally confirmed the anticipated shallow geology of the Sutton Sand Formation and Kellaways Clay Member, however the further underlying strata as shown on the published geological information were not encountered during this investigation due to the shallow nature of the investigation.

Similarly the mounded material to along the western and northern boundaries was not included within the extent of this investigation.

The geology encountered on-site during the intrusive investigation is summarised below. More detail is presented within the exploratory hole logs presented in Appendix B.

Considering the construction of the wellsite, a large ditch separated two distinct areas. The centre of the site predominantly made up of a compact hardstanding (WS02-WS06) and a section of the site along the western and northern boundaries where a material mound had been created (WS01).

Topsoil

Topsoil was recovered in one borehole location (WS01) as a soft consistency dark grey brown slightly clayey fine sand to a depth of 0.40m begl.

Made Ground

Made ground comprising a grey sand and gravel with cobbles of slag, brick, flint and limestone was typically recovered across the area of the site that had been developed for the for the purpose of the extraction well. The made ground material was typical recovered to a depth of 0.30m begl, immediately underling this material was a white membrane.

Sutton Sand Formation

Underlying both the made ground and topsoil natural SSF deposits were typically recovered as a variety of orange becoming grey, brown and green clayey sands, with local pockets of clay. This material was recovered to depths between 2.90m begl (WS02) to 4.50m begl (WS01). The base of this strata was not proven in WS04, WS05 and WS06.

Re-worked Sutton Sand Formation

In a single location (WS02) the SSF recovered between 0.30m begl to 2.40 begl appeared to have been re-worked.

Kellaways Clay Member

Underlying the SSF the KCM was recovered in three boreholes (WS01, WS02 and WS03), typical as blue, grey and brown laminated sandy clay. This material was recovered to depth between 5.00m begl (WS01 and WS02) and 5.50m begl (WS03). The base of this strata was not proven through this investigation.

7.2. Groundwater Observations

Groundwater seepages were noted in two of the exploratory holes WS01 and WS02 throughout the investigation. The seepages were described as wet between 2.00m and 2.40m begl in WS02 and damp at 2.85m begl in WS01.

No groundwater monitoring equipment was installed as part of this investigation.

7.3. Chemical Testing

The results of the chemical testing on soil samples have been reviewed in accordance with the legislative framework and criteria set out in Appendix C.

It is understood that the aims of the chemical testing are to provide a baseline assessment of the site and consider the implications of the current site use. Considering the historical site use of open fields the most stringent assessment criteria has been adopted. Therefore values for a residential land use with home-grown produce scenario has been adopted at this stage.

Where necessary the results of the analysis have been assessed using statistical analysis, as outlined in guidance document CLAIRE 'Guidance on Comparing Soil Contamination Data with a Critical Concentration' (May 2008). Appropriate Upper Confidence Limit (UCL) values have been calculated for those identified strata types with sufficient analysis (i.e. three or more test results).

The chemical test results are presented in Appendix C and any elevated concentrations detailed below.

From the ground investigation, the following strata types were identified:

7.3.1. Topsoil

The total organic carbon (TOC) content of the single sample tested for this horizon is 1.7% equivalent to 2.93% soil organic matter (SOM) content. Therefore, HH GAC based upon a SOM of 1.0% have been adopted.

One sample of this material has been tested for the presence of heavy metals, PAH's and TPH. No exceedances of HH GAC were noted.

One sample from this horizon has been tested for the presence of asbestos. No asbestos fibres were identified.

7.3.2. Made Ground

The TOC content of the five samples tested for this horizon is 0.46% equivalent to 0.79% SOM content. Therefore, HH GAC based upon a SOM of 0.25% have been adopted.

Five samples of this material have been tested for the presence of heavy metals, PAH's and TPH. Six exceedances of HH GAC were noted and are summarised below:

Sample Details	Determinand	Recorded Concentration (mg/kg)	HH GAC Concentration (mg/kg)
WS02 – 0.30m begl	Benzo(b)fluoranthene	1.6	1.2
	Benzo(a)pyrene	1.5	1.2
	Chromium	38	21
WS03 – 0.30m begl	Chromium	54	21
WS04 – 0.30m begl	Chromium	26	21
WS05 – 0.20m begl	Chromium	21	21

Five samples from this horizon have been tested for the presence of asbestos. No asbestos fibres were identified.

7.3.3. Sutton Sand Formation

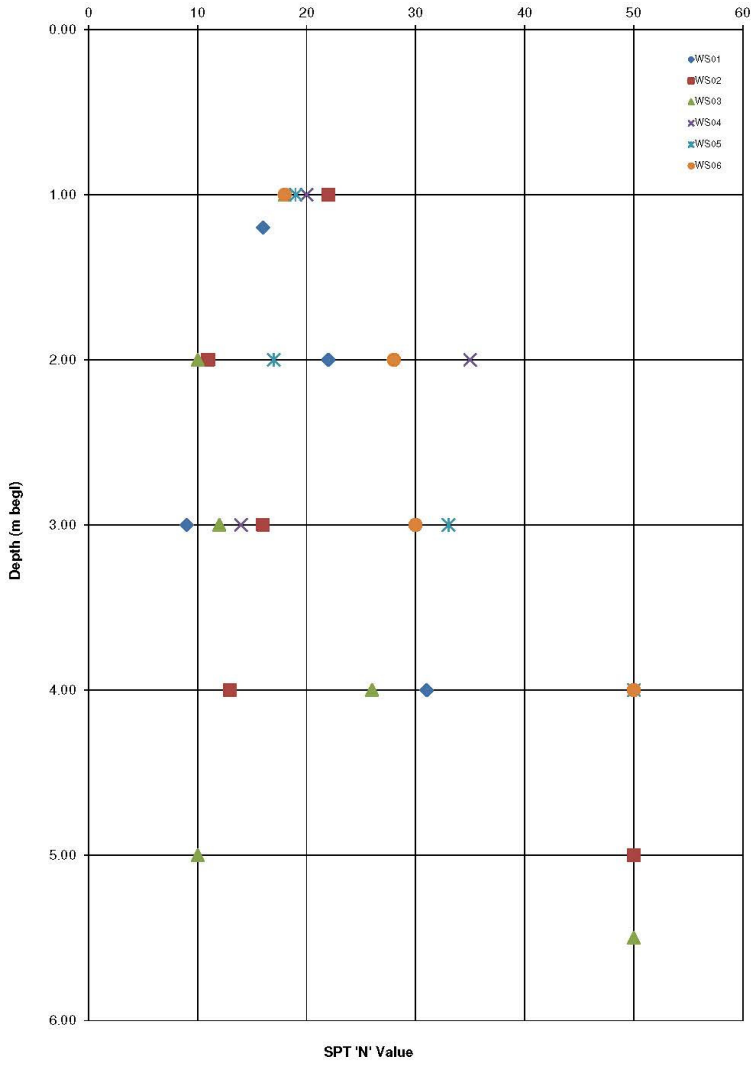
The TOC content of the five samples tested for this horizon is 2.1% equivalent to 3.6% SOM content. Therefore, HH GAC based upon a SOM of 2.5% have been adopted.

Five samples of this material have been tested for the presence of heavy metals, PAH's and TPH. No exceedances were identified.

7.4. Geotechnical Testing

7.4.1. Standard Penetration Testing (SPT's)

In-situ SPT's were recorded at regular intervals in each borehole as shown on the borehole logs contained within Appendix D and shown on the following graph.



7.4.2. Dynamic Cone Penetrometer (DCP) Testing

In-situ DCP testing was undertaken by an Opus engineer in the location of each borehole, the results of the testing have been converted to a Californian Bearing Ratio (CBR) value per strata encountered. These results and the associated CBR values are summarised below. For further detail the full results are contained within Appendix D

Topsoil

Test Location	Test Range (m begl)	Blow Count	CBR Value (%)
WS01	0.0 – 0.40	9	5.5

Made Ground

Test Location	Test Range (m begl)	Blow Count	CBR Value (%)
WS02	0.0 – 0.30	34	30.2
WS03	0.0 – 0.30	55	50.3
WS04	0.0 – 0.30	1	0.7
WS05	0.0 – 0.30	2	1.5
WS06	0.0 – 0.30	17	14.5

Sutton Sand Formation

Test Location	Test Range (m begl)	Blow Count	CBR Value (%)
WS01	0.40 - 0.95	14	6.2
WS02	0.30 - 0.90	87	39.2
WS03	0.30 - 0.90	72	32.1
WS04	0.30 - 0.905	33	14.0
WS05	0.30 - 0.90	83	37.3
WS06	0.30 - 0.90	88	39.4

8. Assessment & Recommendations

8.1. Introduction

This report has been prepared on the understanding that the site is to remain as a wellsite. Should the proposed site usage change significantly from the above, the contents of this report will require review and amendment as appropriate. It is also understood that this report is to act as a baseline assessment of the previous site conditions and is to act to evaluate the desk based preliminary site conceptual against the current site conditions. This report will also make comment on the likely effect of the current site use on the current condition of the site.

The ground conditions encountered throughout this investigation are typified by the presence of made ground or natural topsoil typically underlain by orange, brown and grey green sands (Sutton Sand Formation). This strata is typically underlain by grey brown clay of the Kellaways Clay Member.

9. Environmental Assessment

9.1. Soil Contamination Summary

The results of the laboratory testing undertaken have been assessed in accordance with the philosophy and Tier 1 screening values presented in Appendix C. Considering that this assessment is design to represent an assessment of the site prior to the current use as a well site, it has been considered prudent to adopt the most stringent screening values typically adopted for residential with home grown produce.

For the purposes of risk assessment the following strata types were identified:

- Topsoil
- Made Ground
- Sutton Sand Formation

The full results of the chemical testing are enclosed as Appendix C, however, the results are discussed below:

9.1.1. Topsoil

One sample of this material has been analysed, no exceedances of HH GAC were detected. It is considered that this material is likely representative of the topsoil that would have been located across the site prior to the current site use.

9.1.2. Made Ground

Five samples of this material have been analysed and six exceedances of HH GAC were detected.

Elevated levels of total chromium were noted in four borehole locations (WS02, WS03, WS04 & WS05) within the made ground material. At this stage to adopt a conservative approach the total concentration of chromium has been evaluated against the criteria for chromium VI. However, given this adopted conservative approach, further testing to derive specific chromium speciation may demonstrated that this strata does not exceed the HH GAC criteria.

Further to this two exceedance of PAH's were noted within the made ground material analysed with the location of borehole WS02. These exceedances of HH GAC were noted as Benzo(b)fluoranthene and Benzo(a)pyrene and were identified as very minor exceedances. Should the site be returned to original state, of an open field, then remediation of this material may be required. Given the nature of this material the elevated PAH level could be a result of the on-site activity or similarly be a result of previous location or transportation of the material.

9.1.3. Sutton Sand Formation

In total five samples of this material were analysed no exceedances of HH GAC were identified, therefore this material is considered unlikely to be affecte by contamination risk identified within the desk study.

9.1.4. Baseline Assessment

Considering the natural material recovered on-site (SSF and Topsoil) the results of the chemical testing demonstrated no exceedances of HH GAC. With this in mind it would be prudent to assume that this material is representative of the site prior to the wellsite development and as such should be adopted as baseline levels for future assessment and comparison.

As this report is a retrospective assessment and the desk study has been completed following the site works no testing of pesticides and herbicides was undertaken. It is recommended that these are tested within the natural strata.

The made ground material recovered on-site demonstrates some small exceedances of chromium and PAH's in accordance with HH GAC criteria for residential properties with home-grown produce. However, it should be noted that this material was imported on to site as part of the wellsite development, and as part of the decommissioning and return to original use the material should be removed. Considering this the made ground material is not considered a risk at this stage.

10. Geotechnical Assessment

10.1.1. Geotechnical Parameters

The geotechnical properties of the soils were determined by correlations of the strata identified on-site, SPTS and the laboratory test results.

The parameters considered suitable for the use in the geotechnical design are provided in the table below utilising principals set out within Eurocode 7.

Strata	Geotechnical Parameter	Characteristic Value	
		DA1 – C1	DA1 – C2
Made Ground	Bulk Unit Weight, γ (kN/m^3)	20	20
Sutton Sand Formation	Bulk Unit Weight, γ (kN/m^3)	18	18
	Angle of Shearing resistance, ϕ (°)	34	28.4
	Undrained Shear Strength, Cu (kPa)	N/A	N/A
	Average SPT N Value	25	25
	Poissons Ratio, V´	0.2	0.2
Kellaways Clay Member	Bulk Unit Weight, γ (kN/m^3)	18	18
	Angle of Shearing resistance, ϕ (°)	27	22.2
	Undrained Shear Strength, Cu (kPa)	58 - 140	41 - 100
	Average SPT N Value	28	28
	Poissons Ratio, V´	0.5	0.5

10.1.2. CBR Parameters

Considering the in-situ DCP testing that was undertaken on-site the following average CBR values for the material encountered on-site have been derived.

Topsoil – 5.5%

Made Ground – 19.44%

Sutton Sand Formation – 28.03%

It should be noted that the made ground material tested at each location had been disturbed prior to commencement of the test to allow for removal of the underlying membrane. As such it would be prudent to assume that a higher CBR value is achievable. It is therefore considered prudent undertake in-situ plate load CBR testing at ground level to further evaluated the place made ground.

10.1.3. Concrete Classification

The chemical testing results have been assessed for potential aggressivity to buried concrete in accordance with the Building Research Establishment: Special Digest 1 – Concrete in Aggressive Ground (2005).

In accordance with Part 1 of BRE: Special Digest 1, it is considered that the materials at the site can be assigned Design Sulphate Class DS-1 and an ACEC (Aggressive Chemical Environment for Concrete) Class AC-1.

11. Further Works

The following further works have been recommended:

a) Consider herbicides and pesticide testing of the natural strata to provide a baseline assessment.

b) Undertake in-situ plate load testing if further CBR testing is required.

c) Post completion assessment of the ground conditions on removal of the wellsite.