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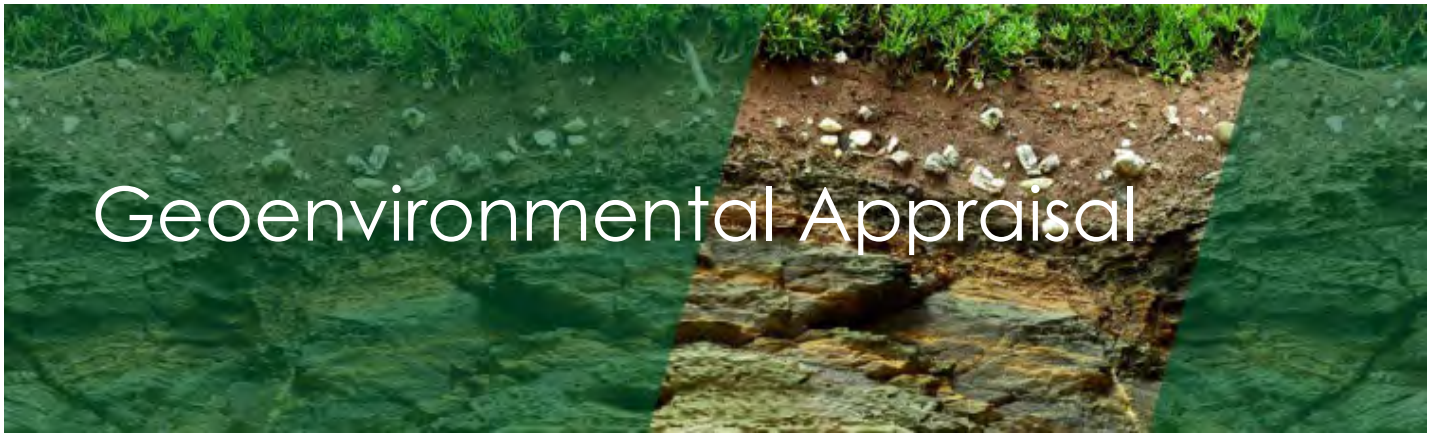

Land at Wakefield Road, Pontefract

For Frontline Estates Ltd

Report no: 3822/1

Date: February 2022

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SUMMARY OF GEOENVIRONMENTAL ISSUES

Job No.	3822	**Site area/ha**	0.8 ha (2 acres)
Client:	Frontline Estates Ltd	**NGR:**	SE 453, 214
Site:	Wakefield Road, Pontefract	**Nearest postcode:**	WF8 4HN

The site is located off Wakefield Road, approximately 600m southwest of Pontefract town centre, and currently comprises overgrown vegetation with some derelict and partially demolished buildings. The site has remained relatively unchanged throughout history, with a Priory located in the northeast corner and the remainder of site covered by woodland.

The site has been subject to quarrying of sandstone and significant depths of quarry backfill underlie c. 50% of the proposed development area.

Lithos were commissioned by Frontline Estates to provide a geoenvironmental appraisal of the site, which it is understood is to be redeveloped with traditional 2/3 storey domestic dwellings with associated gardens, POS and adoptable roads and sewers. Lithos' investigation included a review of the site's history and environmental setting, and a ground investigation comprising 15 trial pits and 4 boreholes.

A summary of salient geoenvironmental issues is provided in the table below.

Issue	Remarks
Made ground	Made Ground typically comprises: • Granular Made Ground: • Quarry Backfill: • Reworked Natural: slightly gravelly Sand with frequent inclusions of dark grey sandy clay. In **Area A**, Granular Made Ground was encountered to 0.9m depth underlain by Quarry Backfill to depths of up to 5.8m. Reworked Natural Material (made ground) was encountered between 5.8m and 9.4m.
Natural ground	Yellow Sands Formation (formerly Basal Permian Sand) from 0.3m in the east of the site to greater the 4.0m in the west of the site, underlain by Newstead Rock sandstone (formerly Pontefract Rock) encountered between 0.6 and 9.4m depth.
Contamination	The made ground has yielded elevated concentrations of a number of metals; most notably lead, copper, arsenic and zinc, as well as elevated organic contaminants in 2 locations. Therefore, the Granular Made Ground and Quarry Backfill should be isolated beneath a 600mm clean cover comprising at least 150mm of Topsoil and 450mm Subsoil over a 150mm hard-dig layer. Alternatively, a high-visibility contaminated ground warning / marker barrier, such as Lotrak Alarm18 could be placed beneath the soil cover. The proposed cover should sufficiently isolate end users from the contaminants found to date.
Mining & quarrying	Whilst the site lies within a Coal Authority Low Risk area, no significant risks have been identified, and an intrusive mining investigation will not be required. Our investigation revealed approx. 50% of the site has been subject to quarrying. There are no formal records documenting the quarrying, with the footprint not recorded on historical maps. Granular Made Ground underlies the majority of the site, to relatively shallow depths in **Area B** (up to 0.3m) and to greater depths in **Area A** (up to 0.9m) particularly in the centre of the site. Deep Quarry Backfill underlies c. 0.4 ha (50%) of the total site area, comprising predominantly brick, concrete, glass, ceramic and fragments of metal, wood, paper, plastic etc. to varying depth of between 2.0m and 4.0m (maximum >5.8m). In the far west, the Quarry Backfill is underlain by Made Ground consisting of reworked natural material (comprising sand and gravel with cobbles) to a depth of 9.4m. Depth of Made Ground (Quarry Backfill & Re-worked natural) increases from less than 1.0m in the centre of the site at the eastern extent of the infilled quarry, to around 9.4m in the west (in BH01). An adit is present in the northern part of the site (Area B). The entrance is partially secured by wooden planks, however, beyond this the descending tunnel is filled with various items, including wooden stakes, brick waste, and a shopping trolley. The purpose of the adit, its lateral and vertical extents are unknown, with investigation of the adit beyond the scope of this site investigation.
Hazardous gas	The site is in an area where 1-3% of homes are estimated to be above the radon action level. Radon protection is not required, but the Developer might consider providing new dwellings with basic measures in light of Public Health England advice. The site is underlain by deep quarry backfill. Consequently, a hazardous gas risk assessment is required, along with monitoring of the installed gas monitoring wells. At this stage it would be prudent to assume that Amber 2 protection measures will be required. This will need to be confirmed via monitoring.

SUMMARY OF GEOENVIRONMENTAL ISSUES

Job No.	3822	**Site area/ha**	0.8 ha (2 acres)
Client:	Frontline Estates Ltd	**NGR:**	SE 453, 214
Site:	Wakefield Road, Pontefract	**Nearest postcode:**	WF8 4HN

Issue	Remarks
Preparatory works	Demolition of buildings & grubbing up of hardstand. Consideration should be given to turnover (excavation, screening and replacement in engineered layers) of the uppermost 2m to 3m of made ground and possibly the full thickness of Tipped Material in order to: • Remove shallower oversize (sandstone boulders). • Remove/regrade the moderately steep slope (c. 2.0m height) separates two "terraces" in **Area B**. • Improve the ground below proposed new highways
Foundations	The site can be divided into two broad areas in terms of likely foundation requirements for new plots: • Shallow strips/trench-fill footings in the east (**Area B**) - c. 60% of plots • Piled foundations in the west (**Area A**) - c. 40% of plots Turnover the full thickness of made ground will not be possible and therefore some boulders may remain at depth. Consequently, some pre-boring or revision of the piling layout is likely to be required. There is the potential for settlement of the ground in external areas around piled plots, and consideration should be given to mitigation measures.
Groundwater & excavations	Groundwater was not encountered during our investigation. Excavations through made ground are likely to be unstable even in the short term & if shallow.
Flooding & drainage	The site lies in Flood Zone 1 where the risk of flooding is low. Soakaways will not provide a suitable means of water disposal & alternative means will be required.
Highways	Where made ground is present its full thickness (up to a maximum of 2m from existing ground level or proposed highway formation, whichever is the lower) should be excavated and either replaced with suitable aggregate or be screened to allow selection of suitable material, before being replaced in engineered layers. Where the made ground is re-engineered it is considered that a CBR value of at least 3% should be achievable. However, this should be verified by field trials.

Significant developer abnormals relating to geoenvironmental issues at the site are:

- Deep quarry backfill (**Area A**) requiring:
  - Earthworks turnover & site regrade
  - Piled foundations
  - (Probable) gas protection measures; in the absence of monitoring, at this stage assumed to be Amber 2
  - Consideration of the potential for settlement of the ground around piled plots
- A buried former quarry "ramp" sloping at c. 30 degrees, running broadly north-south between **Areas A** & **B**
- Placement of 600mm soil cover plus 150mm "hard dig" in proposed gardens and POS.
- Adit located in the northern part of **Area B**

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APPENDICES

Appendix A - General notes

01	Environmental setting
02	Ground investigation fieldwork
03	Geotechnical testing
04	Contamination laboratory analysis & interpretation

Appendix B - Drawings

Drawing	Revision	Title
3822/1	-	Site location plan
3822/2	-	Proposed site layout
3822/3	-	Site features
3822/4	-	Site photographs
3822/5	-	Preliminary conceptual site model
3822/6	-	Exploratory hole locations
3822/7	-	Revised conceptual site model
3822/8	-	Site Areas

Appendix C - Commission

Appendix D - Historical OS plans#

Appendix E - Search responses#

From	Date	Content
Landmark	28/10/2021	Environmental search data
Coal Authority	28/10/2021	Mining report
BGS	28/10/2021	Environmental search data

Appendix F - Exploratory records

Appendix F	TP01 to TP10 & TP101 to TP103
Appendix G	BH01 to BH04

Appendix H - Chemical test results

Appendix I - Contaminated land assessment for selection of water supply pipes

Appendix J - Geotechnical test results

Some of this data is not included within the paper or PDF copies of this report; by request, it can be provided on a CD.

FOREWORD (geoenvironmental appraisal report)

This report has been prepared for the sole internal use and reliance of the Client named on page 1. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Lithos Consulting Limited (Lithos); such authorisation not to be unreasonably withheld. If any unauthorised third party comes into possession of this report, they rely on it at their peril and the authors owe them no duty of care and skill.

This report has been reviewed by a Competent Person, as defined in the National Planning Policy Framework. We ensure that all projects are managed by individuals with necessary experience, relevant qualifications, and current membership of a relevant professional organisation. Records of engineers, project managers and reviewers involved in this project are maintained by us. Lithos QA/QC procedures for all our work forms an integral part of our ISO9001 accreditation and as such is regularly audited.

The report presents observations and factual data obtained during our site investigation and provides an assessment of geoenvironmental issues with respect to information provided by the Client regarding the proposed development. Further advice should be sought from Lithos prior to significant revision of the development proposals.

The report should be read in its entirety, including all associated drawings and appendices. Lithos cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context. However, it should be noted that in order to keep the number of sheets of paper in the hard copy to a minimum, some information (e.g. full copy of the Landmark/Groundsure Report) is not included in the pdf, by request, it can be provided on a CD.

The findings and opinions conveyed in this report (including review of any third-party reports) are based on information obtained from a variety of sources as detailed within this report, and which Lithos believes are reliable. Reasonable care and skill has been applied in examining the information obtained. Nevertheless, Lithos cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

The report represents the findings and opinions of experienced geoenvironmental consultants. Lithos does not provide legal advice and the advice of lawyers may also be required.

Intrusive investigation can only investigate shallow ground beneath a small proportion of the total site area. It is possible therefore that the intrusive investigation undertaken by Lithos, whilst fully appropriate, may not have encountered all significant subsurface conditions. Consequently, no liability can be accepted for conditions not revealed by the exploratory holes. Any opinion expressed as to the possible configuration of strata between or below exploratory holes is for guidance only and no responsibility is accepted as to its accuracy

It should be borne in mind that the timescale over which the investigation was undertaken may not allow the establishment of equilibrium groundwater levels. Particularly relevant in this context is that groundwater levels are susceptible to seasonal and other variations and may be higher during wetter periods than those encountered during this commission.

Where the report refers to the potential presence of invasive weeds such as Japanese Knotweed, or the presence of asbestos containing materials, it should be noted that the observations are for information only and should be verified by a suitably qualified expert.

Lithos cannot be responsible for the consequences of changing practices, revisions to waste management legislation etc that may affect the viability of proposed remediation options.

Lithos reserve the right to amend their conclusions and recommendations in the light of further information that may become available.

GEOENVIRONMENTAL APPRAISAL
of land at
WAKEFIELD ROAD, PONTEFRACT

1 INTRODUCTION

1.1 The commission and brief

1.1.1 Lithos Consulting Limited were commissioned by Frontline Estates Ltd to carry out a geoenvironmental appraisal of land at Wakefield Road.

1.1.2 Correspondence regarding Lithos' appointment, including the brief for this investigation, is included in Appendix C. The agreed scope of works included:

- A site walkover and inspection
- An assessment of the land use history
- Determination of the site's environmental setting
- A mining risk assessment in accordance with Coal Authority guidance
- An intrusive ground investigation comprising 15 trial pits and 4 boreholes
- Assessment of the geotechnical properties of the near surface deposits to enable provision of foundation and highway recommendations
- A qualitative assessment of contamination risks
- Recommendations for the necessary site preparatory and remediation works

1.1.3 Primary aims of this investigation were to identify salient geoenvironmental issues affecting the site to support the submission of a planning application, and also to enable Frontline Estates to obtain budget costs for: foundations; gas protection measures; and site preparatory and remediation works.

1.2 The proposed development

1.2.1 It is understood that consideration is being given to redevelopment of the site with 22no 2/3 storey domestic dwellings, associated gardens, POS, adoptable roads and sewers.

1.2.2 A site layout has been provided by Frontline Estates (Drawing reference 3132-1-001-D, dated 02/05/2019) which is reproduced as Drawing 3822/2 in Appendix B to this report.

1.3 Report format and limitations

1.3.1 All standard definitions, procedures and guidance are contained within Appendix A, which includes background, generic information on:

- Assessment of the site's environmental setting
- Ground investigation fieldwork
- Geotechnical testing
- Contamination testing

1.3.2 General notes and limitations relevant to all Lithos geoenvironmental investigations are described in the Foreword and should be read in conjunction with this report. The text of the report draws specific attention to any modification to these procedures and to any other special techniques employed.

1.3.3 In accordance with the agreed scope of works, the ground investigation reported here is not fully compliant with Eurocode 7 (EC7) and this report does not purport to be a Ground Investigation Report, nor a Geotechnical Design Report as defined by EC7. The ground appraisal, parametric assessment and preliminary design guidance presented are intended to assist others as they prepare the design of the proposed works.

2 SITE DESCRIPTION

2.1 General

2.1.1 The site's location is shown on Drawing 3822/1 presented in Appendix B to this report. Site details are summarised in the table below.

Detail	Remarks
Location	600m southwest of Pontefract town centre
NGR	SE 453 214
Approximate area	0.8 ha (2 acres)
Known services	Underground services around former Priory

2.2 Site features

2.2.1 Lithos completed a walkover survey of the site on 29th October 2021.

2.2.2 Existing salient features, at the time of the walkover are presented on Drawing 3822/3 in Appendix B to this report and summarised in the table below.

Feature	Remarks
Current Access	Off Wakefield Road
Topography	The northern part of the site is relatively flat, with the southern half on higher ground, above a quarry rock face, however this is not within the development footprint.
Approximate areas	1500m^2 buildings 1000m^2 tarmac hardstand 5500m^2 vegetation
Nature of boundaries	North – housing and Wakefield Road East, West – housing South – quarry high wall, woodland and residential beyond
Surrounding land uses	North – housing and Wakefield Road East, west & south – housing

2.2.3 Access to the site is via an unnamed private road off Wakefield Road to the north west of the site.

2.2.4 A rough gravel track runs from the northwest corner towards the centre of site, and gives access to a number of garages situated on the northern boundary.

2.2.5 An unused brick garage/workshop is located adjacent to the gravel track in the western part of site, containing various household items such as old mattresses, gas bottles and a BBQ. Power is provided to the building via underground cables to the north.

2.2.6 Various locked metal contains, approx. 5, are located across the western half of the site.

2.2.7 The southern and south-eastern areas of the site were inaccessible due to overgrown vegetation, trees and steep slopes. The southern boundary of the western half of the site, comprises an approximately 10m high sandstone quarry face.

2.2.8 A derelict building, and surrounding outbuildings, known as The Priory is located in the north-eastern corner of site. Concrete roof sheets were noted in this area, possibly containing asbestos.

2.2.9 An adit entrance is present in the north-eastern part of site, roughly opposite The Priory. The entrance is partially secured by wooden planks, however beyond this the descending tunnel is filled with various items, including wooden stakes, brick waste, and a shopping trolley.

2.2.10 The purpose of the adit, its lateral and vertical extents are unknown, however, it is likely that the adit is associated with the former Priory rather than Yellow Sands Formation extraction. Investigation of the adit is beyond the scope of this site investigation.

2.2.11 A selection of site photographs is included on Drawing 3822/4.

3 SITE HISTORY

3.1 Site centred extracts from Ordnance Survey (OS) plans dating back to 1852 have been examined. Some of these plans are presented in Appendix D to this report.

3.2 The table below provides a summary of the salient points relating to the history of the site. It is not the intention of this report to describe in detail all the changes that have occurred on or adjacent to the site. Significant former uses/operations are highlighted in **bold** text for ease of reference.

Date	Site	Surrounding land
1852	Labelled as **Priory Wood**	**Pontefract** town to the northeast and east Area to the south labelled **Mill Hill**
1893	Building labelled **The Priory** shown in northeast corner	Area labelled **Old Quarry** approx. 100m north
1907	No significant changes	**Old Quarry** now labelled **Tanshelf Mills** Area labelled **Water Works** approx. 150m west
1922	Steep topography indicated in the southwest (possibly associated with quarrying)	No significant changes
1933	No significant changes	Fields to the west labelled **Allotment Gardens**
1952		**Tanshelf Mill** no longer labelled **Water Works** no longer labelled Further expansion of Pontefract to the south and west
1967		No significant changes
1971		
1978		
1993		
2000		
2021		

4 ENVIRONMENTAL SETTING

4.1 General

4.1.1 Notes describing how the site's environmental setting has been assessed are included in Appendix A to this report. Reference has been made to publicly available Government held digital data via QGIS (an Open Source Geographic Information System). Extracts from the response received from Landmark, and responses from the Coal Authority and the BGS are presented in Appendix E. These responses are summarised below, together with the findings of our own "desk study" investigation.

Issue	Data reviewed	Summary
Geology	1:50,000 BGS map (Sheet 078) 1:10,000 BGS map (Sheet SE42SE)	Drift soils – None anticipated. Solid (bedrock) – Newstead Rock Sandstone (formerly Pontefract Rock) and Yellow Sands Formation (formerly Basal Permian Sand), with the Cadeby Formation (Dolostone and Limestone) in the southwest corner. Shallowest coal seam – Low Barnsley Seam at about 425m depth. Faults – none within the site boundary.
Mining	Coal Authority	This site is located within a Coal Mining Development Low Risk Area (within the defined coalfield, but no known defined risks have been recorded by the Coal Authority; there may still be unrecorded issues) Past and present workings – none recorded at the site. Opencast – none within 500m. Mine entries – none within 100m.
Quarrying	Historical OS plans	Historical maps suggest that areas around the site and directly south have been quarried, most likely extracting the Yellow Sands Formation, however there is no evidence from historic maps that the site itself has been quarried. Though quarrying may have occurred prior to 1852.
Landfills	Envirocheck Report	No known landfills within 250m.
Radon	Public Health England	The site lies in an area where 1-3% of homes are estimated to be above the action level. Further details in Section 11.
Hydrogeology	Environment Agency electronic open data via QGIS	Not within a Groundwater Source Protection Zone Aquifer: Secondary A Aquifer (Newstead Rock), Principle Aquifer (Cadeby Formation). Groundwater abstractions? None within 1000m of site. Pollution incidents? Significant incident reported on site in December 2001 - biodegradable material and waste, including vegetable cuttings.
Hydrology	Environment Agency Envirocheck Report	Nearest watercourse(s) – Wash Dyke (approx. 1km east) leading to the River Aire. Water quality - Moderate. Pollution incidents? None of significance. Abstractions? None within 250m of site. Discharge consents? None within 250m of site.
Flood risk	Environment Agency electronic open data via QGIS	The site lies in Flood Zone 1, where the risk of flooding from rivers or the sea is classified as low.

Issue	Data reviewed	Summary
		In accordance with Chapter 10 of the National Planning Policy Framework, a site-specific flood risk assessment is required for proposals of 1 hectare or greater in Flood Zone 1, or in an area within Flood Zone 1 which has critical drainage problems (as notified to the local planning authority by the Environment Agency).

4.2 Ground stability

4.2.1 Given that the site is underlain by Yellow Sands Formation (Basal Permian Sand) and Cadeby Formation bedrock, it was considered prudent to obtain a natural ground stability report from the BGS in order to check whether or not the limestone bedrock is considered prone to dissolution resulting in underground cavities that could lead to surface collapses and hollows.

4.2.2 The BGS report (copy included in Appendix E) provides an indication of the potential for natural ground instability to occur within, and within 50m, of a site. It is auto-generated from BGS's GeoSure dataset. The Report assigns hazard levels for shrink-swell (clays), landslides (slope instability), soluble rocks (dissolution), compressible ground, collapsible deposits and running sand, but it does not include mining related subsidence. Hazards are graded on a scale from A to E (low to high), but Levels A & B are considered insignificant.

4.2.3 The BGS report for this site suggests:

- Soluble Rocks (dissolution); Rocks that can dissolve and develop underground cavities that may lead to surface collapses and hollows – **No risks identified** .
- Compressible Ground; Very soft ground that might compress and progressively sink under the weight of a building – **No risks identified.**
- Running Sand; Sand that can wash away or flow into holes or fissures due to presence of water **Level C**. The source of this hazard will also be the Yellow Sands Formation (Basal Permian Sands) in the far southeast, and issues of excavation stability are discussed further in Section 16.7.

5 PRELIMINARY CONCEPTUAL SITE MODEL

5.1.1 Historical plans do not show the presence of a quarry on the site, however the site is underlain by the Yellow Sands Formation (Basal Permian Sands), which is known to have been quarried in the Castleford-Pontefract area since the late 1700s.

5.1.2 Therefore, if the site has been quarried in the past, then it is likely that the land would have been backfilled to match existing levels once quarrying is complete. As a consequence of this, anticipated potential contaminants, within soil and/or groundwater might include:

- Heavy metals
- Asbestos
- Total Petroleum & Polyaromatic Hydrocarbons (PAH & TPH)
- Volatile & Semi-Volatile Organic Compounds (VOC & sVOC)

5.1.3 A preliminary conceptual site model, presented as Drawing 3822/05 in Appendix B, has been prepared after consideration of all the data presented in Sections 2 to 4.

5.1.4 Clearly, the conceptual model will be subject to modification in light of data arising from the proposed intrusive ground investigation.

5.1.5 Potential contaminant linkages are shown on the preliminary conceptual site model.

6 GROUND INVESTIGATION DESIGN

6.1 Anticipated ground conditions & potential issues

6.1.1 Based on the data reviewed in Section 4 (Environmental Setting) anticipated ground conditions are expected to comprise:

Anticipated condition	Remarks
Made ground	Not anticipated, however could be present in areas if the site have been backfilled following quarrying.
Natural soils	No superficial deposits expected.
Bedrock	Likely to be Newstead Rock (Pontefract Rock) Sandstone and Yellow Sands Formation (Basal Permian Sand), with Cadeby Formation in the south-west corner.
Mineworkings	None likely.
Groundwater	Deep groundwater is likely within the bedrock.

6.1.2 Based on the data above and that in Sections 2 (Site Description) and 3 (History), potential ground-related issues associated with this site are likely to include:

Type of issue	Specific issue	Remarks
Potential on-site contamination sources	1. Backfilled quarry	1. Backfill may include degradable or contaminated materials.
Potential off-site contamination sources	1. Backfilled quarries	1. Potential for pollution of groundwater
Potential geotechnical hazards	1. Relict buried obstructions 2. Deep MG 3. Steep slopes 4. Adit	1. Derelict buildings on-site 2. In areas of former quarries 3. Quarry face 4. Unknown purpose in northeast of site
Other potential constraints	1. Underground and/or overhead utilities	1. Will require easement or diversion

6.2 Ground investigation design & strategy

6.2.1 The preliminary conceptual site model was used as a basis for design of an appropriate ground investigation, the scope of which is summarised below.

Exploratory holes	Purpose
10 Trial Pits	To determine the general nature of soils underlying the site, including the: • Presence, nature, distribution and thickness of made ground • Nature, degree and extent of contamination • Proportion of undesirable elements e.g. biodegradable matter, foundations etc • Suitability of the ground for founding structures and highways

6.2.2 Proposed exploratory hole locations were selected to provide a representative view of the strata beneath the site and to target potential areas of interest identified in Section 5 above. A nominal 30m grid spacing was proposed. Additional exploratory locations might be scheduled by the site engineer in light of the ground conditions actually encountered.

6.2.3 The number of representative samples taken will be reflective of the geological complexity actually encountered. However, in general about 3 samples will be taken from most trial pits.

7 FIELDWORK

7.1 Objectives

7.1.1 The original investigation strategy is outlined in Section 7.2 above.

7.1.2 The additional exploratory holes listed below were advanced in light of ground conditions actually encountered.

Exploratory holes	Purpose
Trial Pits 11 & 12	To enable better delineation of the depth and lateral extent of the made ground in the south west
Trial Pits 101 to 103	To delineate the lateral extent of areas which have been subject to past quarrying.
4 Cable Percussive Boreholes	To determine the nature, extent and depth of backfill in the former quarry. To confirm the strength (density) of natural in-situ granular soils via SPTs. To install monitoring wells across the site in order to: • Monitor for hazardous gas

7.2 Exploratory hole location constraints

7.2.1 No access was available in the south east and the north west corner due to overgrown vegetation, woodland, steep slopes and existing buildings. Areas which were inaccessible are shown on Drawing 3822/6 presented in Appendix B.

7.3 Scope of works

7.3.1 Fieldwork was supervised by Lithos on 10th November 2021 and 9th to 11th February 2022 and comprised the exploratory holes listed below.

Technique	Exploratory holes	Final depth(s)	Remarks
Trial pitting (machine excavated)	TPs 1 to 12 & TPs 101 to 103	1.2 to 3.5m	Vane tests in cohesive soils
Boreholes (Cable Percussive)	BH01 to 04	3.0 to 9.5m	SPT testing throughout

7.3.2 Notes describing ground investigation techniques, in-situ testing and sampling are included in Appendix A to this report.

7.3.3 Exploratory hole logs are presented in Appendix F & G to this Report. These logs include details of the:

- Samples taken
- Descriptions of the solid strata, and any groundwater encountered.
- Results of the in-situ testing
- The monitoring wells installed

7.3.4 Exploratory hole locations are shown on Drawing 3822/6 presented in Appendix B; hole positions are based on data from a hand-held GPS (typically +/- 3m accuracy) and have not been surveyed in.

8 GROUND CONDITIONS

8.1 General

8.1.1 A complete record of strata encountered beneath the proposed development site is given on the various exploratory hole records, presented in Appendix F & G.

8.1.2 The site can be divided into 2 areas based on ground conditions. These areas are shown on Drawing 3822/08 and are summarised below:

Site area	General location	Area (m^2)
A	Western half of the site, where suspected sandstone quarrying took place	3,200
B	Eastern half of the site	4,800

8.1.3 Typical ground conditions encountered at the site are described below in Sections 9.2 (made ground) and 9.4 (natural ground), with a summary provided in the table on page 11.

8.2 Made ground

8.2.1 The made ground on site is a heterogeneous mixture of materials and it is unlikely, even with a huge amount of sampling, that it could be accurately characterised. Nonetheless, the bulk of the made ground can be categorised as one of 3 broad types:

- **Granular Made Ground:** typically comprises very sandy, Gravel of brick, concrete, ceramic, plastic and metal. Encountered in 8 of the 15 trial pits, to a maximum depth of 0.9m.
- **Quarry Backfill:** comprising very sandy Gravel of brick, concrete and sandstone, with frequent cobbles. Encountered in 10 of the 15 trial pits to depths in excess of 3.5m and in 3 of the 4 boreholes to depths of up to 5.8m. Only encountered in **Area A**.
- **Reworked Natural:** comprising loose to medium dense slightly gravelly Sand with dark grey clay inclusions, encountered between 2.5m and 9.4m depth within TP103 and BH01.

8.2.2 Review of the trial pit and borehole logs suggest made ground thicknesses beneath the site vary between 0.4m and 9.4m. The thickest made ground was encountered in the south, close to the sandstone quarry highwall, with depth generally increasing from east to west.

8.2.3 Deeper made ground is typically restricted to the southwest; likely associated with backfilling of a former sandstone quarry.

8.3 Obstructions

8.3.1 It is apparent from a review of historical OS Plans (see Section 3) and the site visit that buildings have been present on about 10% of the site area. Furthermore, concrete hardstand, which is typically 300mm thick, covers approximately $100m^2$. Drawing 3822/3 shows the footprints of the former structures, and areas of hardstand.

8.3.2 Constraints associated with existing buildings have prevented trenching to identify and assess the nature/extent of buried obstructions. However, the existing buildings will have foundations, and other below ground structures should be anticipated.

8.3.3 In addition to the obstructions described above, large oversize materials such as masonry boulders and stone lintels were encountered, most notably within the **quarry backfill** made ground. It is estimated that within this made ground type approximately 40% of the material is coarser than a housebrick.

8.3.4 Given the redevelopment proposals, removal of obstructions and oversize will be required.

8.4 Natural ground

8.4.1 Natural ground was encountered in 13 of the 19 of the exploratory holes, and typically comprised:

- **Topsoil:** sandy Clay was identified in just 3 locations (TP08, TP09 and BH04) to a typical depth of 200mm.

- **Yellow Sands Formation (Sandstone):** comprises light yellow brown Sandstone, recovered as sandy tabular gravel and cobbles of sandstone. Encountered in 12 locations from 0.1m to 5.8m depth. Encountered mainly in **Area B**, and at greater depths in **Area A** due to extensive made ground.
- **Newstead Rock (Sandstone):** comprising reddish brown and yellow Sandstone recovered as sandy tabular gravel and cobbles of sandstone. Only encountered in TP06, in the far east of the site. Likely to be the very dense material encountered at the base of BH01, 02 and 03.

Summary of Ground Conditions

Hole ID	Final Depth (mbgl)	Base of Topsoil (mbgl)	Depth to base of: (mbgl)			Depth to: (mbgl)		Remarks
			Made Ground			Natural		
			Granular	Quarry Backfill	Re-worked Natural	Yellow Sands Formation (Basal Permian Sandstone)	Newstead Rock (Pontefract Rock)	
TP01	3.5	-	0.6	>3.5	-	-	-	-
TP02	3.0	-	0.9	>3.0	-	-	-	-
TP03	3.5	-	0.4	>3.5	-	-	-	-
TP04	3.0	-	-	>3.0	-	-	-	-
TP05	2.0	-	0.5	-	-	0.5	-	Difficult to excavate below 2.0m
TP06	1.3	-	0.6	-	-	-	0.6	Difficult to excavate below 1.3m
TP07	1.2	-	0.4	-	-	0.4	-	Difficult to excavate below 1.2m
TP08	2.7	0.2	-	-	-	0.2	-	Complete collapse at 2.7m
TP09	2.0	0.1	-	-	-	0.1	-	Complete collapse at 2.0m
TP10	3.0	-	0.1	>3.0	-	-	-	Difficult to excavate below 3.0m
TP11	1.8	-	0.2	0.6	-	0.6	-	Difficult to excavate below 1.8m
TP12	3.3	-	-	>3.3	-	-	-	Difficult to excavate below 3.2m
TP101E	2.0	0.2	-	-	-	0.3	-	-
TP101W	2.0	-	0.3	1.0	-	1.0	-	-
TP102E	2.0	0.2	-	-	-	0.2	-	-
TP102W	2.5	-	0.2	2.5	-	-	-	-
TP103	3.5	-	0.2	1.0	2.5	2.5	-	-
BH01	9.5	-	-	5.8	9.4	-	9.4	At 9.4m - Chiselled for 30 minutes, advancing 100mm.
BH02	6.0	-	-	4.3	-	4.3	6.0	At 6.0m - Chiselled for 30 minutes, advancing approx. 50mm.
BH03	4.8	-	-	4.0	-	4.0	4.8	At 4.8m - Chiselled for 30 minutes, advancing approx. 30mm.
BH04	3.0	0.2	-	-		0.3	-	-

8.5 Visual & olfactory evidence of organic contamination

8.5.1 Exploratory locations where evidence of significant organic contamination was noted are summarised below:

Site area	Hole	Material	Depth (m)	Observation
Area A	TP02	Granular Made Ground	0.6	Organic odour, presence of timber

8.5.2 Selected samples of potentially contaminated materials were scheduled for chemical testing to determine the nature and extent of the identified contamination; see Section 11.

8.6 Groundwater

8.6.1 No significant inflows of groundwater were encountered during the investigation.

8.7 Stability

8.7.1 Stability of excavations within natural strata and made ground was generally good, with some collapse within the Yellow Sands Formation.

9 CONTAMINATION (ANALYSIS)

9.1 General

9.1.1 The site's former usage is likely to have given rise to some ground contamination, associated with backfilling of the former sandstone quarry. Furthermore, significant thicknesses of made ground were encountered in many of the exploratory locations during the ground investigation.

9.1.2 An assessment of potential contaminants associated with the former uses has been undertaken; see Section 5.

9.1.3 In the context of risks to human health associated with residential redevelopment, the Tier 1 Soil Screening Values referenced in this report have been derived via the CLEA default conceptual site model (CSM) used for generating SGVs, but amended, where appropriate, to be more specific to redevelopment within the planning process.

9.1.4 Where available, Category 4 Screening Levels (C4SL) have also been referenced.

9.1.5 Generic Note 04 in Appendix A provides further details with respect to current guidance and the interpretation of analytical data.

9.2 Testing scheduled

9.2.1 Based on the above assessment, Lithos submitted a test schedule (summarised in the table below) to a UKAS accredited laboratory. Account has also been taken of visual and olfactory evidence recorded during the ground investigation.

Type of sample	No. of samples	Determinands
Made ground	16	pH, water soluble boron, and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc) & Asbestos ID Water soluble sulphate, chloride, nitrate and magnesium TOC, Speciated Polycyclic Aromatic Hydrocarbons (PAH)
	1	Banded Total Petroleum Hydrocarbons (TPH)

9.2.2 Account was taken of previous uses in specific areas, with analysis concentrated on samples recovered from the vicinity of former backfilled quarries.

9.3 Soil contamination results

9.3.1 The soil contamination test results are summarised in the tables on pages 14 to 16.

9.3.2 Laboratory test certificates as received from the laboratory are presented in Appendix I to this report.

Summary of degree of soils contamination (inorganics)

Expl Hole	Depth (m)	Material	Concentrations in mg/kg unless otherwise stated. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are shown in BLUE and assume a **residential with gardens** end-use.											
			pH	As ∞	B~	Cd ∞	Cr x	Cu♣$	Pb ∞	Hg*	Ni	Se	Zn$	CV	Asbestos
				37	5	26	3000	200	200	169	127	350	200	2	
TP01	0.2	Granular Made Ground	10.6	6.1	1.40	0.3	320	35	25	< 0.05	9.3	2.6	49	-	**N.D.**
TP02	0.6	Granular Made Ground	9.2	12	1.3	0.6	14	110	**200**	1.2	14	0.6	**360**	-	**N.D.**
TP05	0.3	Granular Made Ground	9.7	**49**	0.7	0.2	29	**500**	**270**	0.18	39	1.2	110	-	**N.D.**
TP06	0.5	Granular Made Ground	8.1	8.9	0.5	0.1	7.9	20	47	0.11	11	< 0.5	36	-	**N.D.**
TP07	0.2	Granular Made Ground	8.7	20	0.4	0.1	9.5	44	**210**	0.18	16	< 0.5	44	-	**N.D.**
TP01	0.8	Quarry Backfill	9.5	17	0.7	0.3	35	50	170	0.17	14	< 0.5	110	-	**N.D.**
TP01	2.7	Quarry Backfill	8.6	10	1.4	0.30	7	18	44	0.11	10	< 0.5	55	-	**N.D.**
TP02	2.0	Quarry Backfill	8.1	24	1.6	0.50	20	78	**610**	0.6	20	< 0.5	**260**	-	**Amosite**
TP03	0.4	Quarry Backfill	8	19	0.9	3.70	19	48	**350**	0.26	25	0.9	120	-	**N.D.**
TP03	2.0	Quarry Backfill	8.1	25	1.2	0.3	21	61	170	0.14	28	1.3	80	-	**N.D.**
TP04	0.5	Quarry Backfill	8.8	12	1	0.4	12	45	**590**	0.16	12	< 0.5	120	-	**N.D.**
TP04	1.0	Quarry Backfill	9.1	20	1.2	0.2	10	48	**1100**	0.29	15	< 0.5	78	-	**N.D.**
TP10	0.4	Quarry Backfill	8.1	9.6	1.2	0.5	9.3	30	66	0.09	13	< 0.5	84	-	**N.D.**
TP11	0.4	Quarry Backfill	9.3	16	0.8	0.7	15	46	150	0.22	21	< 0.5	**200**	-	**N.D.**
TP12	0.5	Quarry Backfill	8.3	11	1	0.4	13	31	91	0.15	11	0.7	80	-	**N.D.**
TP12	1.2	Quarry Backfill	8.3	8.5	0.9	0.2	12	27	57	0.13	10	< 0.5	59	-	**N.D.**

Key	
36	Parameter tested for and found to be in excess of Tier 1 value.
179	Parameter tested for and found to be > 5 x Tier 1 value.
12	Parameter tested for but not found to be in excess of Tier 1 value.
	Parameter not tested for.
♣	Tier 1 Value is pH dependent.
x	Assumes Cr is CrIII. If demonstrated Cr is CrVI Tier 1 would be 21mg/kg.
ND	No fibres detected (asbestos screen)

Source of guidance trigger level	
With the exception of those annotated with one of the symbols below (∞, $, ~), all Soil Screening Values in brackets above have been derived using CLEA v1.071.	
∞	Category 4 Screening Level – SP1010, December 2013 (CL:AIRE/Defra).
$	MAFF. Code of Practice for Agricultural Practice for the Protection of Soil, 1998.
~	Engineering judgement (Lithos). Boron is a phytotoxic, although most phytotoxic compounds can pose a risk to human health if sufficient concentrations are present. However, plants represent the most sensitive receptor, and a Tier 1 value which is protective of flora is therefore also protective of human health.
*	Assumes mercury present as an inorganic compound (cf elemental metal or within organic compound). See Science Report SC050021/Mercury SGV.

Expl Hole	Depth (m)	Material	Concentrations in mg/kg. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are shown in BLUE and assume a **residential with gardens (and no cover)** end use							PAH		TPH - C6 to C40		
			% TOC	Benzene ∞	Toluene	Ethyl Benzene	Xylenes	Phenols	PCB	B(a)P ∞	Naphthalene	GRO~ C_6 to C_{10}	DRO◊ C_{10} to C_{21}	LRO C_{21} to C_{40}
				0.9	600	350	246	412	2	5	8	30	151	1000
TP01	0.2	Granular Made Ground	6.2	-	-	-	-	-	-	**11**	0.06	-	-	-
TP02	0.6	Granular Made Ground	5.1	-	-	-	-	-	-	0.12	< 0.03	<0.1	<30	<20
TP05	0.3	Granular Made Ground	8.0	-	-	-	-	-	-	**6.5**	0.07	-	-	-
TP06	0.5	Granular Made Ground	1.2	-	-	-	-	-	-	0.06	< 0.03	-	-	-
TP07	0.2	Granular Made Ground	2.6	-	-	-	-	-	-	1.1	< 0.03	-	-	-
TP01	0.8	Quarry Backfill	1.9	-	-	-	-	-	-	0.47	0.06	-	-	-
TP01	2.7	Quarry Backfill	2.6	-	-	-	-	-	-	0.04	< 0.03	-	-	-
TP02	2.0	Quarry Backfill	6.7	-	-	-	-	-	-	0.15	< 0.03	-	-	-
TP03	0.4	Quarry Backfill	6.5	-	-	-	-	-	-	0.04	< 0.03	-	-	-

Expl Hole	Depth (m)	Material	Concentrations in mg/kg. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are shown in BLUE and assume a **residential with gardens (and no cover)** end use										
			% TOC	Benzene ∞	Toluene	Ethyl Benzene	Xylenes	Phenols	PCB	PAH		TPH - C6 to C40		
										B(a)P ∞	Naphthalene	GRO~ C_6 to C_{10}	DRO◊ C_{10} to C_{21}	LRO C_{21} to C_{40}
				0.9	600	350	246	412	2	5	8	30	151	1000
TP03	2.0	Quarry Backfill	7.0	-	-	-	-	-	-	< 0.03	< 0.03	-	-	-
TP04	0.5	Quarry Backfill	3.9	-	-	-	-	-	-	0.05	0.07	-	-	-
TP04	1.0	Quarry Backfill	6.0	-	-	-	-	-	-	0.06	< 0.03	-	-	-
TP10	0.4	Quarry Backfill	6.0	-	-	-	-	-	-	1.5	0.36	-	-	-
TP11	0.4	Quarry Backfill	3.7	-	-	-	-	-	-	0.75	0.52	-	-	-
TP12	0.5	Quarry Backfill	5.5	-	-	-	-	-	-	1.6	0.3	-	-	-
TP12	1.2	Quarry Backfill	3.8	-	-	-	-	-	-	1.2	0.16	-	-	-

Key		**Source of Guidance Trigger Level**	
0.3	Parameter tested for but not in excess of Tier 1 concentration	All Soil Screening Values in brackets above have been derived using CLEA v1.06. Values assume contaminants located in a sandy loam, with 6% soil organic matter (SOM). Assumes **no soil cover**, see Generic Notes 04 in Appendix A.	
60	Parameter tested for and in excess of Tier 1 concentration	~	Assumes all GRO is aromatic fraction C7 to C8
-	Contaminant not tested for	◊	Assumes all DRO is aliphatic fraction C10 to C12
		∞	Category 4 Screening Level – SP1010, December 2013 (CL:AIRE\Defra)

Inorganic determinands

9.3.3 Of the 16 samples of Granular Made Ground and Quarry Backfill analysed for inorganic parameters, 8 can be classified as uncontaminated and 8 could be classified as contaminated.

9.3.4 These samples have been classified by comparison with Tier 1 Soil Screening Values for an end use including domestic gardens and any area where plants are to be grown (the most sensitive of proposed end-uses).

9.3.5 The most common contaminants are; copper, lead, zinc and arsenic.

9.3.6 Current UK guidance regarding the statistical analysis of soil contamination data obtained during a site investigation is provided by CL:AIRE[1], and uses two-way confidence intervals and graphical summaries, to assist assessors when determining whether or not a dataset is adequate to answer the question posed; e.g. "is existing site topsoil suitable for retention & re-use?". To answer such a question, it is necessary to recover and test a large number of samples (a minimum of 10; ideally 20+) in order to undertake meaningful statistical analysis.

9.3.7 However, in the context of site investigation to assess the significance of contamination on brownfield sites which are typically underlain by heterogenous made ground, some remediation is almost always required (placement of soil cover, excavation of gross contamination etc). Consequently, in such circumstances, it is not usually necessary to demonstrate that made ground soils are "clean" and therefore there is no need to test large numbers of samples and undertake statistical analysis. Heterogenous made ground sample results can simply be compared directly with appropriate screening values (e.g. Lithos Tier 1 values).

9.3.8 The difference between the old and new approaches, including how Lithos apply the statistical assessment is detailed in Generic Note 04, included as Appendix A to this report.

9.3.9 Lithos can confirm that statistical assessment of the quarry backfill is not appropriate because:

- Sampling locations were clustered around a source area
- There are insufficient samples from the quarry backfill to allow representative statistical assessment to be undertaken.

Asbestos

9.3.10 No asbestos fibres were identified in any of the Granular Made Ground or Yellow Sands Formation samples screened.

9.3.11 Screening for asbestos identified fibres (Chrysotile) in one of the 11 samples of quarry backfill tested. As such, further analysis (asbestos quantification) was instructed to determine the significance of this result.

9.3.12 Results of the quantification show that these positive results are associated with the presence of trace amounts of fibre (0.001%) and are therefore of limited significance.

[1] *CL:AIRE, 2020.Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration.*

Organic determinands

9.3.13 This site is brownfield and underlain by made ground which has yielded elevated concentrations of a number of inorganic determinands. Consequently, for organic compounds, the Tier 1 Soil Screening Values used in this report have been derived with reference to a CSM that assumes a minimum 600mm of clean soil cover will be placed in gardens/landscaped areas (Lithos Scenario B).

9.3.14 Lithos have used the CLEA model to derive risk-based screening values for hydrocarbons, in accordance with the methodology detailed by the TPHCWG, and reviewed by a UK workshop of experts with respect to UK adoption of the method.

9.3.15 However, these screening values assume a Soil Organic Matter (SOM) of 6% (equivalent to a TOC of 3.5%). Many organic contaminants are more mobile when the SOM is lower, and consequently comparison of soil results with lower screening values may be required.

9.3.16 In order to check the validity of Lithos' Tier 1 Soil Screening Values, the average TOC for each common fill type (beyond any areas of obvious hydrocarbon impact) have been determined.

Fill type	Typical TOC (%)	Comparison of soil results with revised screening value necessary?
Granular Made Ground	>5%	No

Hydrocarbons (TPH & PAH)

9.3.17 Given the previous uses of the site and the absence of visual/olfactory evidence of any hydrocarbon contamination in all but one location, a simple banded TPH (cf full speciation) was scheduled on just 1 sample.

9.3.18 Assessment of TPH associated with a fuel/oil source would normally be undertaken in accordance with a 3-step approach, (outlined in Generic Note 04 in Appendix A) on fully speciated TPH results. However, although only banded TPH analysis has been scheduled here, none of the fractions exceed their respective Tier 1 criteria, even if it is conservatively assumed all of each fraction is either aliphatic or aromatic.

9.3.19 Consequently, no significant petroleum hydrocarbon concentrations have been identified, and there is no risk to human health from these hydrocarbons.

Polycyclic Aromatic Hydrocarbons (PAH)

9.3.20 There are numerous PAH compounds. The USEPA identified 16 PAHs that are considered to represent the most problematic in terms of toxicology, fate and behaviour. The UK have also focused on these 16 and these are included in the laboratory report where speciated PAH analysis has been scheduled.

9.3.21 Speciated PAH analysis has been undertaken in order to determine concentrations of the key "marker" compounds: benzo(a)pyrene (considered the most toxic of the PAHs); and naphthalene (the most mobile and volatile of the PAHs).

9.3.22 Speciated analysis has confirmed the presence of benzo(a)pyrene in 2 samples (TP01 and TP05). Consequently, remediation is required.

9.4 Topsoil

9.4.1 Topsoil (and made ground topsoil), typically 200mm thick is present across limited parts of **Area B**. Testing suggests this material is not suitable for re-use, due to elevated inorganics.

BS3882 Topsoil testing

9.4.2 The presence of visible contaminants, sharps (glass etc) was assessed by the Engineer in the field (inspection of initial trial pit arisings); Some fragments of glass and plastic were identified. BS3882 considers visual contaminants to comprise 'undesirable potentially injurious foreign object(s) visible to the naked eye'.

9.4.3 Due to the limited amount of topsoil present on the site, the clay/sand/silt content of 1 topsoil sample has been determined to check compliance with BS3882[2] requirements.

9.4.4 It should be noted that this is a reduced suite of analysis, and no N-P-K etc. testing has been undertaken.

9.4.5 The result is summarised below:

Parameter	BS3882 Specification	TP08 – 0.1-0.3m
Retained on 2mm sieve	< 30%	4%
Retained on 20mm sieve	< 10%	2%
Retained on 50mm sieve	0%	0%
Clay content	5 to 35%	15.6%
Silt content	0 to 65%	25%
Sand content	0 to 90%	59.4%
Visible contaminants	< 0.5%	**5%**

Note: Values in **bold** type fail the required specification for multipurpose topsoil

9.4.6 The results of the chemical testing and the percentage of visible contaminants (glass, plastic etc) suggest that the onsite topsoil is **not** suitable for reuse in residential gardens.

10 CONTAMINATION (QUALITATIVE RISK ASSESSMENT & REMEDIATION)

10.1 Topsoil

10.1.1 Natural Topsoil, typically 200mm thick was encountered in just two locations in **Area B** and comprises sandy Clay. Made Ground Topsoil covers the majority of the site, testing suggests the this material is not suitable for reuse.

10.1.2 Much of the Topsoil and Granular Made Ground has been found to be contaminated with inorganic contaminants. In addition, the made ground types include a significant portion of undesirable near-surface materials (glass, metal, brick etc).

10.1.3 Given the compressible nature and gas-generating potential of the existing topsoil if buried at depth, it is recommended that it is placed in garden areas and/or POS, immediately beneath the proposed 600mm cover and 150mm hard to dig layer.,

10.2 Revised conceptual ground model (contamination)

10.2.1 The Preliminary Conceptual Site Model has been revised in light of data obtained during the ground investigation, most notably with respect to:

- The extents of former quarries and buried highwalls

10.2.2 Further refinement of the Conceptual Site Model is presented in Sections 10.4, where the results of laboratory testing for contaminants have been considered.

[2] *BS3882:2015. Specification for topsoil. Published by BSI Standards Limited.*

10.3 Summary of significant contamination

10.3.1 Made Ground underlies the majority of the site to depths of up to 9.4m.The Made Ground predominantly comprises:

- Granular Made Ground (typically within the former quarry to depths of to 0.9m depth; **Area A**),
- Made Ground Topsoil (across the entire site to depths of up to 0.3m),
- Quarry backfill (within the former quarry to depths of up to 5.8m; **Area A**) and
- Reworked Natural Fill (at depth within the former quarry; **Area A**).

10.3.2 Granular Made Ground has yielded elevated concentrations of both inorganic and organic contaminants; likely associated with on-site tipping.

10.3.3 Quarry Backfill has yielded elevated concentrations of inorganic contaminants, as well as (relatively minor amounts of) asbestos.

10.3.4 Furthermore, both the Granular Made Ground and the Quarry Backfill include a number of materials which would be considered undesirable at or near surface in a residential setting; e.g. glass, metal, concrete, brick etc.

10.3.5 No significant remediation should be required, but some preparatory works will be necessary to render the site suitable for development; see Section 17.2.

10.4 Revised conceptual ground model (contamination)

10.4.1 The Preliminary Conceptual Site Model has been amended in light of data obtained during the ground investigation, most notably with respect to the distribution of made ground and contaminants.

10.4.2 A revised Conceptual Site Model is presented as Drawing 3822/07 in Appendix B. The Model includes the contaminants described in Section 12.3 above, and potential contaminant linkages (summarised below in Section 10.6) to receptors.

10.5 Environmental setting & end use

10.5.1 As discussed in Section 10.3 above, contamination exists in the Granular Made Ground and Quarry Backfill beneath this site. In order to assess the significance of this contamination, consideration must be given to the site's environmental setting and the proposed end use.

10.5.2 The underlying Newstead Rock is classified as a Secondary A aquifer. The nearest surface watercourse is the Wash Dyke, which flows in an easterly direction, approximately 1km beyond the site's eastern boundary. Therefore, the site's environmental setting is considered to be **low sensitivity**.

10.5.3 With respect to human health, the proposed end use (residential) is considered **sensitive**.

10.5.4 Transient risks to construction workers can be addressed by the adoption of appropriate health and safety measures, see Section 14.6.

10.6 Contaminant linkages

10.6.1 In terms of a proposed redevelopment of this site, plausible contaminant linkages can be summarised as follows.

Contaminants

10.6.2 Contaminants have been summarised in Section 10.3.1 above.

Pathways

10.6.3 Potential contaminant pathways include:

- Ingestion
- Dermal contact
- Inhalation of contaminated particulates
- Surface water run-off, including existing drainage infrastructure

Receptors

10.6.4 Potential contaminant receptors include:

- The environment – underlying bedrock aquifer (Secondary A) & plant growth
- End users of the site (residents)
- Site workers (construction)

10.6.5 It can be concluded that there are plausible pathways between the soil contaminants summarised in Section 10.3.1 above and potential receptors (i.e. end users). Consequently, some remediation will be required; either treatment/removal of the contaminant, or "breakage" of the pathway.

10.7 Potential remediation options

General

10.7.1 Approval of the recommendations given below should be sought from the appropriate regulatory authorities prior to commencement of site redevelopment.

Asbestos

10.7.2 CL:AIRE has published a Joint Industry Working Group (JIWG) guidance[3] document with the support of the Health & Safety Executive which provides an explanation of how legal requirements of the Control of Asbestos Regulations 2012 have been interpreted to be more directly applicable to the risks associated with asbestos contaminated soil and construction & demolition materials.

10.7.3 As discussed in Section 9.3, an asbestos ID (screen) was scheduled on 20 samples of made ground and quarry backfill, with asbestos identified in 1 sample. Supplementary analysis (asbestos quantification) of this sample show that this positive result is associated with the presence of trace amounts of fibre (0.001%) and are therefore of limited significance. Risks associated with trace amounts are negligible and the proposed 600mm cover will afford additional protection.

10.7.4 Any fragments of asbestos cement sheeting encountered during the excavation works, should be gathered by hand and placed in double sealed bags. Personnel involved in this activity must be equipped with an appropriate respirator (i.e. a FFP3 or better), in addition to their "standard" PPE. The bags of asbestos waste should be placed in a sealed skip for off-site disposal at a suitably licensed landfill site; such material will be classified as hazardous waste.

[3] *Control of Asbestos Regulations 2012: Interpretation for Managing and Working with Asbestos in Soil and Construction & Demolition materials: Industry Guidance. CL:AIRE, 2016.*

10.7.5 Made ground where asbestos has been positively identified and considered representative of near-surface soils, should ultimately be isolated beneath a minimum 600mm thick surface cover of "clean" soil (garden/landscaped areas), or hardstand (parking areas), or floor slabs (buildings) and therefore there will be no risk of release of asbestos fibres from the ground.

10.7.6 Where made ground remains in garden areas or POS, it would be prudent to place a minimum 150mm "hard dig" layer of crushed demolition arisings immediately beneath the soil cover. Alternatively, a high-visibility contaminated ground warning / marker barrier, such as Lotrak Alarm18 could be placed beneath the soil cover.

10.7.7 New utilities should be laid in trenches reinstated with 'clean' backfill in order to prevent exposure to maintenance workers in the future.

10.7.8 See also comments in the 'Waste Classification' Section below.

Inorganic contamination

10.7.9 The made ground has yielded elevated concentrations of a number of metals; most notably lead, copper, arsenic and zinc. Therefore, where residual made ground remains beneath garden and landscaped areas (i.e. not beneath hardstanding) a **600mm** thick surface cover of "clean" soil comprising 450mm subsoil and 150mm topsoil plus 150mm "hard dig" layer (or warning / marker barrier) is recommended. This cover will break potential contaminant linkages between the contaminated made ground and future end-users.

Organic contamination

10.7.10 As discussed in Section 9.3 above, hydrocarbon contamination has been encountered. Such contaminants can be mobile and as such may pose a risk to the environment and human health.

10.7.11 Based on a qualitative review of the data obtained to date, it would be prudent to allow for the presence of some grossly contaminated soil, which if encountered will require off-site disposal or treatment. Further advice should be sought from a specialist contractor, with experience of brownfield remediation, regarding an appropriate contingency.

10.7.12 Given the anticipated 600mm cover, Lithos Scenario B Screening Values (see Generic Note 4 in Appendix A) could be adopted as target concentrations for remediation.

10.7.13 Remediation options worthy of further consideration at this stage are summarised below:

Remediation techniques (organic contamination in soil)

Technique	Remarks	Feasibility
Excavation & disposal	Not in line with current Government philosophy regarding sustainable development. Might be appropriate given relatively small volume and site's size/location.	Likely to be more expensive and less sustainable
Isolation beneath cover	No significant volatiles component and site's environmental setting with respect to controlled waters is of low sensitivity, therefore soil cover might be appropriate.	Likely to be most suitable

Groundwater & surface water

10.7.14 As discussed in Section 8.6 above, no significant water contamination has been encountered.

10.7.15 Groundworkers should make all necessary arrangements to prevent off-site migration of contaminants via surface water runoff, inadvertent groundwater disturbance and airborne dust.

10.8 Summary of potential contaminant linkages & mitigation

10.8.1 In terms of the proposed redevelopment plausible contaminant linkages, and feasible remediation options, can be summarised as follows:

Receptors	Pathways	Contaminants	Plausible contaminant linkage? (and remediation options where required)
Human health (Future residents) ◊	Consumption of contaminated vegetables	**Granular Made Ground** & **Quarry Rubble** – inorganics, hydrocarbons	Yes – Isolation beneath at least 600mm clean soil cover in garden and landscaped areas
	Ingestion		
	Dermal contact		
	Inhalation (dust and/or vapours)		
	Infiltration of water supply pipes		Treatment or removal of any encountered hydrocarbons Water company may still insist of "protectaline" pipework
Groundwater (secondary A aquifer)	Surface water run-off		Surface waters will be partly intercepted & channelled into drainage runs reducing volume of water contacting contaminated soils.
Buildings	Migration & accumulation of explosive gas	Methane	To be assessed on completion of monitoring and gas risk assessment

◊ transient risks to construction workers will be addressed by the adoption of appropriate health and safety measures in accordance with the Health and Safety at Work Act 1974 and regulations made under the Act including for example the COSHH Regulations.

10.9 Waste classification

10.9.1 Disposal of the made ground off site is generally not considered appropriate, economically viable, nor in line with current Government philosophy regarding sustainable development. However, some excess arisings may be generated by excavations for foundations, sewers etc. Disposal to landfill (or an appropriate soil / aggregate transfer station) may be the most practical solution, if redistribution and retention on site is not feasible.

10.9.2 Following excavation and stockpiling, sampling will be required prior to disposal.

10.9.3 As there is no WRAP protocol for soils, the characterisation, sampling and classification of soils arising from brownfield sites has been incorporated within the Environment Agency's Technical Guidance WM3[4]. Classification of soils as non-hazardous or hazardous in accordance with WM3 is quite a complex process, although it ultimately results in a simple classification as hazardous or non-hazardous. Note: inert is not a class under WM3; WAC testing is required to determine whether a waste soil can be considered inert.

10.9.4 If waste soil is classed as hazardous following classification under WM3, and destined for landfill, waste acceptance criteria (WAC) leachate testing will need to be undertaken. Similarly, if waste soil destined for landfill is classed as non-hazardous under WM3, and suspected to be inert, WAC leachate testing will need to be undertaken. However, non-hazardous soil waste can go to a non-hazardous landfill facility; no further testing (e.g. WAC) is required.

[4] *Technical Guidance WM3 – Guidance on the classification and assessment of waste. Environment Agency 2015*

10.9.5 WAC analysis is different to the 'routine' laboratory testing (such as that included earlier in this Section) undertaken in order to determine hazardous properties. Lithos typically only include WAC analysis if significant off-site disposal (of soil classified as hazardous waste) is anticipated.

10.9.6 It is critical if material is to be exported from site that this is allocated an appropriate waste code, following the steps within WM3. Waste carriers transporting, and sites accepting, this material should have a corresponding code within their permits. It is the responsibility of those generating the waste (i.e. the site), to ensure that the waste is handled and disposed of appropriately.

10.9.7 Soil treatment facilities (STFs) provide an alternative to landfill. STFs are regulated by the Environment Agency and allow soils to be treated and screened (effectively recycled to be used at other sites). Export to an STF does not require WAC testing and suitability of various soil types will be dependent on material waste codes, which may be allocated after consideration of the data in Section 12 but will often need supplementing with further testing after soils have been stockpiled (see also advice in Section 17.3).

10.9.8 Most STFs are permitted to accept soils with waste code 17 05 04 (i.e. soils which do not exhibit hazardous properties). Lithos has a list of permitted STFs and can help identify one local to this development site.

10.9.9 With respect to **asbestos**, waste soils will be classed hazardous if the soil mass contains more than 0.1% asbestos fibres that are free and dispersed. However, WM3 states that where the waste contains identifiable pieces of asbestos (i.e. any particle of a size that can be identified as potentially being asbestos by a competent person if examined by the naked eye), then the waste is hazardous if the concentration of asbestos in the pieces alone is 0.1%. If a stockpile of soil contained rare fragments of broken asbestos-cement sheeting, the whole stockpile would be classed as hazardous unless all the fragments could be picked-out (even though the concentration of asbestos in the soil mass might be orders of magnitude less than 0.1%).

10.9.10 A limited amount of tarmac hardstand is present in the east of **Area B**.

10.9.11 This **tarmac** could be recycled and crushed to yield a 6F3 selected granular material, provided the recovered bitumen content is less than 10% (determined in accordance with BS598-1[5]). Crushed tarmac could also be blended with crushed concrete etc to generate 6F2 graded material. 6F2 can contain up to 50% recycled tarmac/asphalt (provided it does not pose a contamination risk to controlled waters and, if the proportion of asphalt is greater than 20%, the recovered bitumen content is less than 2%).

10.9.12 However, if off-site disposal is anticipated, tarmac assessment is based on the amount of coal tar present, this will vary depending on the age of the tarmac. The assessment is based on the amount of benzo(a)pyrene and has a concentration limit of 50mg/kg.

11 HAZARDOUS GAS

11.1 General

11.1.1 Consideration of the conceptual site model and potential linkages has enabled a preliminary qualitative assessment of risks associated with gas:-

Source	Receptors	Hazard	Pathway	Initial risk
On-site made ground	Human health	Asphyxiation & explosion		

[5] *BS598 (2003) Sampling and examination of bituminous mixtures for roads and other paved areas.*

Source	Receptors	Hazard	Pathway	Initial risk
	Buildings	Explosion	Vertical migration, ingress & accumulation	**Low**: made ground essentially inert, with little observed degradable matter

11.1.2 Given the above, gas monitoring wells have been installed in 4 boreholes across the site, three within and one located outside the infilled quarry. Details of the installations are given on the borehole logs presented in Appendix G to this the report.

11.2 Monitoring of the installations has not taken place at this stage, however monitoring will be required to enable characterisation of the site with respect to ground gas protection.

11.3 Radon

11.3.1 Requirements with respect radon measures are set out in Building Regulations Approved Document C. Probability bandings (based on the proportion of properties in a given area that exceed the Action Level; currently 200 $Bq.m^{-3}$) are used to determine whether a property requires no, basic or full measures.

11.3.2 At present Approved Document C advocates basic measures for the probability banding 3% to 10% (full measures if >10%). However, Public Health England would like to see all new build include basic measures.

11.3.3 The Public Health England UK radon map and the Landmark report indicate that the site is in an area where **between 1% and 3%** of homes are estimated to be above the action level.

11.3.4 Consequently, basic radon protection measures are not required. However, in light of Public Health England advice, the Developer might consider providing all new dwellings with basic radon protection measures.

12 GEOTECHNICAL TESTING

12.1 General

12.1.1 A total of 10 samples of natural soil were delivered to a suitably accredited laboratory with a schedule of geotechnical testing drawn up by Lithos.

12.1.2 The geotechnical laboratory test results are presented in Appendix J to this report.

12.2 Soluble sulphate and pH

12.2.1 In accordance with BRE SD1[6], this site has been classified as brownfield with a mobile groundwater regime.

12.2.2 It is envisaged foundations will extend to depths of about 900mm through made ground and natural strata and samples taken from this depth range have been submitted for pH and water-soluble sulphate (2:1 soil/water extract).

12.2.3 The concentrations of sulphate in the aqueous natural soil extracts of 10 samples were determined. The pH value of each sample has also been determined.

12.2.4 The highest water-soluble sulphate concentration and the lowest pH value for each soil type analysed are shown in the table below.

[6] *BRE Special Digest 1 (2005) – Concrete in aggressive ground.*

Soil type	No. samples tested	Lowest pH values	Highest soluble sulphate concentration (mg/l)
Granular Made Ground	1	9.2	1600
Quarry Backfill	5	8.1	510
Yellow Sands Formation	4	8.1	29

12.2.5 pH values were all above 5.5, therefore concentrations of chloride and nitrate are considered insignificant.

12.2.6 In accordance with Tables C2 of SD1, sub-surface concrete in contact with the Granular Made Ground should be Design Sulphate Class **DS-3**, with the site allocated an ACEC Classification of **AC-3**. Subsurface concrete in contact with the Quarry Backfill should be Design Sulphate Class **DS-2**, with the site allocated an ACEC Classification of **AC-2.** Subsurface concrete in contact with the natural strata should be Design Sulphate Class **DS-1**, with the site allocated an ACEC Classification of **AC-1.**

12.3 Standard penetration test (SPT)

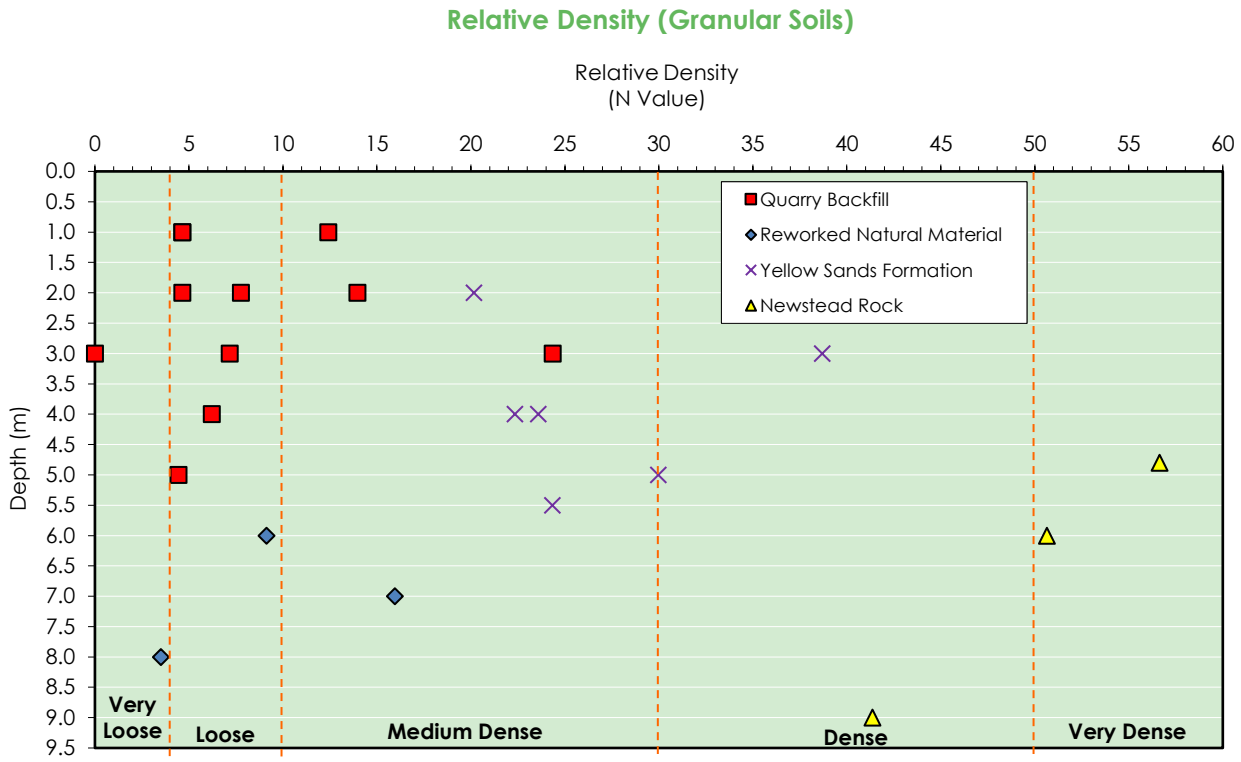
12.3.1 The in-situ relative density of granular soils was established by carrying out Standard Penetration Tests (SPTs) during the drilling of the cable percussion boreholes.

12.3.2 The SPT results are summarised in below:

Stratum	Ave. SPT 'N' value	Estimated strength or density	Remarks
Quarry Backfill	8	Loose	-
Reworked Natural	10	Loose/medium dense	-
Yellow Sands Formation	27	Medium Dense	-
Newstead Rock	50	Very Dense	-

12.3.3 The reported blow counts suggest densities ranging from loose to very dense.

12.3.4 The plot below presents a summary of SPT 'N' values.



12.3.5 The above results confirm observations made during the trial pitting, that the Quarry Backfill is loose, the Yellow Sands Formation is medium dense and the Newstead Rock is very dense.

13 GEOTECHNICAL ISSUES

13.1 Conceptual site model

13.1.1 Ground conditions beneath **Area A** comprise Granular Made Ground to 0.9m depth, underlain with Quarry Backfill to around 5.8m depth and Reworked Natural Fill from 5.8m. The bedrock is Newstead Rock, encountered between 4.8m and 9.4m.

13.1.2 Ground conditions beneath **Area B** comprises granular made ground to c. 0.5m depth over Yellow Sands Formation and Newstead Rock (in the northeast).

13.1.3 Deep Quarry Backfill underlies c. 0.35 ha (40%) of the total site area, comprising predominantly brick, concrete, glass, ceramic and fragments of metal, wood, paper, plastic etc. to varying depth of between 2.0m and 4.0m (maximum >5.8m). The Quarry Backfill is underlain by reworked natural material (comprising sand and gravel with cobbles).

13.2 Mining & quarrying

13.2.1 This site is located within a Coal Mining Development Low Risk Area. However, the shallowest coal seam of note is the Hard Bed Coal at c. 400m depth and the site is not considered to be at risk from underground coal workings.

13.2.2 Our investigation revealed approx. 40% of the site has been subject to quarrying, which is likely to have been prior to 1852.

13.2.3 Depth of backfill increases from less than 1.0m in the eastern part of the infilled quarry, to around 9.4m in the west (in BH01). This suggests there is a buried former quarry "ramp" sloping at c. 30 degrees, running broadly north-south between Areas A & B

Adit Entrance

13.2.4 As discussed in Section 2 there is a known adit within the site's boundary. The purpose of the adit, its lateral and vertical extents are unknown, however, given its location in the north of the site, it is likely that the adit is associated with the former Priory rather than Yellow Sands Formation extraction.

13.2.5 Investigation into the extent and depth of the adit is not within the scope of this investigation. However, further investigation (either intrusive or non-intrusive) is recommended to confirm the full below ground extents of the feature and how it relates to any proposed plots.

13.3 Site regrade and/or ground improvement

13.3.1 Made ground currently underlies approximately half of the site, to an average depth of about 6m; maximum of 9.4m. This made ground is of variable and poor strength and is therefore not considered a suitable foundation material. It has also yielded elevated concentrations of a number of inorganic determinands and contains materials (e.g. brick, concrete etc), which would generally be considered undesirable as a near-surface material in garden areas.

13.3.2 Given the substantial volume of made ground present, export to landfill is not considered economically viable.

13.3.3 Consideration should be given to turnover (excavation, screening and replacement in engineered layers) of the uppermost 2m to 3m of made ground in order to:

- Remove shallower oversize (sandstone boulders).
- Allow redistribution of Granular Made Ground to depths in excess of 1m below proposed final garden levels.
- Improve the ground below proposed new highways.

13.3.4 Because turnover enables inspection of the uppermost layers of fill, the developer and their prospective property purchasers, are provided with the reassurance that no significant hazard is left undetected. This is considered advantageous from a perception viewpoint. Furthermore, any potential for surface water infiltration, which would drive potential leaching of contaminants, should be reduced by compaction.

13.3.5 Given depths of made ground it will not be feasible to turnover the full thickness of made ground and consequently some boulders/obstructions may remain at depth.

13.3.6 Screened and engineered fill should yield CBR values in excess of 3%, thereby reducing abnormals associated with the construction of estate roads and car parking areas. Excavations through the engineered fill, for drainage etc and foundations will not encounter significant obstructions or grossly contaminated ground and should be stable with little overbreak.

13.3.7 The above solution is considered to be in line with current government philosophy regarding sustainable development. Turnover works should be undertaken in accordance with the CL:AIRE Code of Practice (v2, March 2011), and a Materials Management Plan (MMP) should be prepared prior to commencement.

13.3.8 Given existing topography (much of the site is sloping, with gradients of up to 1 in 5 in the centre-east), some site regrade is anticipated, with the need for underbuild and retaining walls.

13.3.9 Careful consideration will need to be given to earthworks design, and implications for slope stability, retaining walls, foundations, highway gradients and drainage.

13.3.10 Any digital terrain modelling undertaken, or commissioned, by Frontline Estates should consider implications for the foundation recommendations outlined below.

13.3.11 Wherever possible, Lithos recommend that excavated soils are retained on site. However, if this is not possible the comments in Section 10.9 should apply.

13.4 Foundation recommendations

General

13.4.1 Foundation recommendations assume that development will be two or three storey construction and that line loads will not exceed 90kN/m run. If this is not the case significant alteration to these recommendations will be required.

13.4.2 Given the existing topography (much of the site is sloping, with gradients of up to 1 in 5 in the centre-east), some site regrade is anticipated, with the need for underbuild and retaining walls.

13.4.3 Foundation depths (and types) will depend on thicknesses of fill following the anticipated earthworks regrade.

13.4.4 Following the anticipated turnover earthworks, replaced fill materials will not contain obstructions and should be relatively stable with little overbreak. At this stage, it is assumed that fill will be placed with nominal compaction only, and reinforced footings on engineered fill are not currently anticipated.

13.4.5 Made ground is not considered a suitable foundation material and foundations should therefore be taken through these materials into underlying natural strata of adequate bearing capacity.

13.4.6 Sub-surface concrete in contact with the made ground should be Design Sulphate Class **DS-3**, with the site allocated an ACEC Classification of **AC-3**.

13.4.7 There are a number of foundation solution options for two or three storey residential properties constructed on this site and these are discussed below.

Strip/trench fill footings

13.4.8 It is considered that shallow strip or deepened trench fill footings will be the most suitable foundation solution for the majority of two or three storey houses constructed in **Area B** on the eastern half of the site. Footings will be founded in competent rock. This solution is viable where the made ground is less than about 2.5m thick, and competent rock is the founding material.

13.4.9 Reinforcement, as a precaution against differential settlement, is recommended only where foundation excavations encounter significant lateral and vertical variations in strata (not expected). One layer of B385 mesh placed 75mm above the base of the footing is likely to provide suitable reinforcement, but further advice should be sought from the Structural Engineer.

13.4.10 Where existing buildings are to be demolished, all concrete slabs and service ducts will require breaking out prior to re-development. However, relict foundations could probably be left in-situ and an allowance made for local breaking out, or (probably better) chased-out and removed during the necessary site preparatory works.

13.4.11 Foundations of plots placed over relict foundations should be taken to greater depth than the relict foundations and into undisturbed natural ground of adequate bearing capacity.

13.4.12 Foundations will be required to be placed below a line drawn up at 45° from the base of any service or similar excavation.

13.4.13 Deepened foundations should be stepped in accordance with NHBC Standards, Chapter 4.3.

13.4.14 In order to minimise softening and swelling of cohesive soils or loosening of granular soils, it is recommended that footings are cast as soon as formation level is reached (or alternatively formation could be blinded using concrete with as low a water:cement ratio as possible).

13.4.15 Whilst strip or trench fill footings generally represent a simple and inexpensive foundation solution, there are a number of potential disadvantages associated with their use on this site:

- The made ground contains elevated concentrations of some inorganic contaminants and a 600mm thick cover of clean subsoil (see Section 10.7) has been recommended. Subject to final remediated development levels, this cover may increase footing depth/underbuild.
- Disposal of arisings will be required.
- Foundation and drainage excavations may encounter significant obstructions resulting in significant overbreak.
- Foundation and drainage excavations will almost certainly require shoring in made ground.

13.4.16 In addition to the above, Frontline Estates should review proposed plot designs and layouts, since deeper excavations for trench fill are likely to be unstable where the centre-lines of parallel trenches are closer than about 2m (assuming 600mm widths). Frontline Estates should supervise their groundworker to ensure footings are excavated in a controlled and safe manner.

13.4.17 Frontline Estates or their groundworker should seek further advice from Lithos if unexpected ground conditions are encountered in foundation or sewer excavations, including any conflict between soft ground associated with a backfilled trial pit excavation and the line of a proposed footing.

13.4.18 The granular Yellow Sands Formation are assumed to have a relative density of at least medium dense (in accordance with BS5930).

13.4.19 A safe bearing capacity of around 150kPa, allowing a maximum foundation line load of 90kN/m run, can be assumed if the following are true:

- A foundation length of 8m
- A foundation breadth of 0.6m
- A foundation thickness of 225mm
- A foundation depth of 0.75m
- Groundwater lies in excess of 1.5m bgl.
- An angle of shearing resistance of ϕ=32° for the granular deposits

13.4.20 Assuming the foundation geometry detailed above, minimal settlements would be anticipated. However, further advice should be sought from the Structural Engineer responsible for foundation design.

13.4.21 The Newstead Rock is generally considered to have a safe bearing capacity of at least 300kPa and minimal settlements would be anticipated.

13.4.22 Where rock is encountered at shallow depth foundations should be placed entirely on rock and not partially on rock and partially on soil. This may, depending on surface gradient, necessitate significant deepening of foundations.

13.4.23 Bedrock at the site comprises sandstone which proved difficult to excavate below 2.0m using a backhoe excavator during the investigation.

Piled foundations

13.4.24 Piled foundations will be the likely solution for dwellings constructed in **Area A**, where deeper made ground was encountered.

13.4.25 The following general comments relating to piling are provided for guidance, and further advice should be sought from a specialist-piling contractor. Piles are likely to be end bearing in bedrock, therefore in accordance with BS 8004[7] and EC7[8], piling contractors may require further boreholes extended a minimum 5m into competent bedrock using rotary coring techniques.

13.4.26 Should any impenetrable shallow obstructions be encountered, i.e. boulders etc, they should either be grubbed-up, or alternatively the piling layout could be re-designed (although this might also require design of foundations able to span and/or cantilever as necessary).

13.4.27 Given the variable depths to bedrock across the site, care should be taken to ensure that piles are not allowed to deflect off any steep under-ground gradients within the rock. This could be achieved by socketing and may require pre-drilling and casing of piles. An allowance should also be made for changing piling locations and ground beam design to account for any difficulties encountered with steep rock gradients associated with the former quarry.

13.4.28 Warranty providers generally require pile lengths to be at least 3m (measured from pile cut off level to pile toe level). Short piles are likely to become dislodged during pile trimming operations, creating additional costs associated with remedial works. Where depths to bedrock vary significantly beneath a plot, pre-boring of piles may be necessary to reach required depths.

13.4.29 Piled foundations should extend into the underlying bedrock. The safe working load that may be supported on a pile is dependent on the pile diameter, its founding depth and the method of installation.

13.4.30 Boreholes indicate that competent sandstone bedrock lies at depths of between 4.0m and 9.5m, below current ground levels.

13.4.31 Consequently, preliminary estimates for pile lengths will be between c. 4.0m and 10m.

13.4.32 In accordance with NHBC Standards, Chapter 4.2, heave precautions should be provided where a plot is within the zone of influence of trees. Table 3b in Chapter 4.2 defines the zone of influence as a function of tree height (between 0.5 and 1.25) dependant on the water demand. Figure 6 in Chapter 4.2 shows where heave precautions are required for pile foundations.

13.4.33 It is recommended that flexible service connections are used on this site, especially where they enter the buildings, in order to avoid any possible damage due to self-settlement of the weak strata once the site is developed.

[7] *BS 8004 (2015) - Code of practice for foundations.*

[8] *BS EN 1997-1:2007. Eurocode 7: Geotechnical design – Part 2: Ground investigation & testing*

13.4.34 Driven piles may lessen the volume of potentially contaminated made ground requiring off-site disposal (cf arisings associated with say trench fill). However, driving can induce some ground vibration. Assessment of any vibration risk to adjacent structures and/or existing site features should be undertaken by pile designer.

13.4.35 New houses can be built off ring beams designed to span the piles. In order to bond them to the piles, the tops of the piles must be broken out to expose the reinforcement, which can then be tied to that of the beams.

13.4.36 Ground conditions at this site are considered likely to require provision of a piling mat (working platform) and further advice should be sought from the appointed specialist-piling contractor regarding the proposed plant loadings and resulting pressures. This data, together with a knowledge of the strength and variability of the near-surface ground conditions is required in order that design of a mat can be undertaken in accordance with guidance provided in the 2004 BRE document, "BR 470: Working platforms for tracked plant".

13.4.37 The design of working platforms for tracked plant is a geotechnical design process and should be carried out by a competent person. The following parties should have input into the design:

- Permanent works designer, to consider additional uses for platform material as part of the overall development
- Principal contractor, to define any other purposes for which the platform might be used
- Contractor or subcontractor, to specify requirements for the platform, including gradients, ramps and edges

13.4.38 The number of plots affected by piling will depend on layout proposals, however, it is considered unlikely to exceed 50% of the total number.

13.4.39 Piles can provide an enhanced pathway for the vertical migration of mobile contaminants. The Environment Agency may therefore object to the adoption of piles as a foundation solution. However, objection is considered unlikely given the nature of the contamination encountered, and the fact that quarry backfill is currently resting directly on the underlying sandstone bedrock.

13.4.40 Pile design should be undertaken in accordance with the Environment Agency's guidance booklet "Piling into Contaminated Sites".

Summary of foundation recommendations

13.4.41 In summary, the following foundation solutions are likely to be most appropriate (subject to Frontline Estates preferences regarding site preparatory works, final levels & costs associated with each foundation option).

Site Area	Foundation solution(s)	Remarks (influencing factors)
A	Piles to between 4.0m and 10m	Made ground associated with backfilled sandstone quarry
B	Strips at 0.75m to 2.0m	Site regrade may increase foundation depth

13.4.42 The foundation solutions outlined in the above table assume that ground levels will not change significantly from those existing at present. If this is not to be the case, further advice should be sought from Lithos.

13.5 Designated concrete mixes

13.5.1 Designated mixes are considered in BRE SD1[9] and BS 8500[10]. However, in addition to soil chemistry (sulphate class), there are a number of other considerations relating to structural design that need to be taken into account when determining an appropriate concrete mix.

13.5.2 Consequently, Frontline Estates should seek advice from their appointed Structural Engineer.

13.6 Excavations

13.6.1 Based on the results of the investigation it is considered unlikely that major groundwater flows will be encountered in shallow excavations.

13.6.2 Groundwater should be controlled in accordance with CIRIA Report R113[11].

13.6.3 Excavations should remain stable in the short term but if left open for any significant period of time may require shoring most notably in granular soils and made ground.

13.6.4 Based on the exploratory hole logs, excavation greater than 2.0m is likely to prove difficult across about 50% of the site. It would therefore be prudent to allow for excavation of **hard rock** in any deep excavations such as those that may be required for drainage etc.

13.7 Drainage

13.7.1 Given the significant thicknesses of made ground encountered on-site soakaway construction will be highly problematic. It should be noted that soakaways cannot be allowed to infiltrate into made ground due to the risk of settlement caused by wash out of fine soil particles.

13.7.2 It is recommended that the developer contact Yorkshire Water Services with respect to capacity in existing foul and surface water sewers in the vicinity of the development area.

13.7.3 Yorkshire Water have published a guide[12] for developers and designers outlining their design requirements for surface water attenuation assets.

13.8 Highways

13.8.1 The natural soils present at shallow depth in **Area B** (Yellow Sands Formation and Newstead Rock) are predominantly granular. Based on visual inspection of the natural materials, published tables[13] indicate that the natural material would be expected to provide a CBR value of at least 5%. These values should be verified prior to or during construction.

13.8.2 Made ground is present across **Area A** and consultation with the adopting authority, regarding the specification of the highways, is strongly recommended.

13.8.3 The made ground present beneath this site is highly variable in terms of both composition, and strength/density. Furthermore, it often contains a significant amount of oversize (boulders etc), which represent potential 'hard-spots'.

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9 *BRE Special Digest 1 (2005) – Concrete in aggressive ground.*

10 *BS 8500-1&2:2015+A2:2019. Concrete. Complementary British Standard to BS EN 206. Method of specifying and guidance for the specifier (1) & Specification for constituent materials and concrete (2).*

11 *CIRIA Report R113 (1986) - Control of Groundwater for Temporary Works.*

12 *Design Requirements for Surface Water Attenuation Assets, February 2017.*

13 *Interim Advice Note 73/06 Revision 1 (2009), Chapter 5. Characterisation of Materials Design Guidance for Road Pavement Foundations - Draft HD25*

13.8.4 Consequently, where made ground is present its full thickness (up to a maximum of 2m from existing ground level or proposed highway formation, whichever is the lower) should be excavated and either:

- replaced with suitable aggregate in accordance with Series 600 (Earthworks) of The Highways Agency (HA) "Specification for Highway Works" 1998; or
- screened, to allow selection of suitable material, before being replaced in engineered layers (in accordance with Series 600). Unsuitable materials include any soft or wet materials, biodegradables including topsoil, wood, scrap metal, frozen material and oversize.

13.8.5 If any new highway spans a quarry 'high-wall' or buried "quarry slope", the following precautions are recommended to protect highway and drainage infrastructure from damage due to differential settlement.

- The made ground should be excavated over the full width of the adoptable highway to at least 1.0m below deepest sewer invert.
- The base of the excavation (1.5m below sewer invert) should be reinforced with two layers of Tensar Triax TX160 (or equivalent) geogrid sandwiched within at least 300mm of suitable aggregate.

13.8.6 A minimum length of 5m either side of any highwalls associated with the former quarry should be treated to the above specification, although the final specification should be agreed with the adopting authority.

13.8.7 Some refinement of the above advice might be possible after highways design (with consideration of the proposed formation level cf existing ground level), and via inspection (and usually CBR testing) of the proposed formation during site preparatory groundworks.

13.8.8 Any residual made ground materials in the base of the excavation should be inspected and (where necessary) any soft spots removed and replaced with suitable engineered fill.

13.8.9 Where the made ground is re-engineered it is considered that a CBR value of at least 3% should be achievable. However, this should be verified by field trials.

13.8.10 Crushing of demolition/hardstand/foundation arisings will generate aggregate, which (subject to confirmatory testing) should be suitable for use as unbound pavement materials within the highways.

13.9 External works

13.9.1 Any digital terrain modelling undertaken, or commissioned, by Frontline Estates should be made available to their Engineering Designer prior to issue of an External Works Drawing.

13.9.2 When designing retaining walls, consideration should be given clause 10.2.3 of NHBC standards which states that flexible retaining walls such as gabion and timber structures should not be used to provide support to homes, garages, roads, drives, car parking areas or drainage systems.

14 REDEVELOPMENT ISSUES

14.1 General

14.1.1 This report has presented options with respect to foundation solutions, treatment of contamination and re-use of topsoil etc that are considered technically feasible and in line with current good practice. Consequently, we would expect to obtain regulatory approval for whichever option is adopted, although this cannot be guaranteed. Copies of this report should be forwarded to the relevant regulatory authorities (Warranty Provider & Local Authority) for their comment/approval.

14.1.2 Even after an appropriate preliminary investigation and ground investigation, with exploratory holes on a closely spaced grid (say trial pits at 30m centres), a geoenvironmental appraisal is typically based on inspection of the ground underlying less than 0.5% of the total site area (and much less at depths in excess of about 3.5m). Consequently, there is always a possibility that unanticipated ground conditions will be encountered during the construction phase.

14.1.3 If unanticipated ground is encountered during the construction phase, the Contractor should immediately seek further advice from the Engineer.

14.2 Remediation strategy

14.2.1 Redevelopment of this site will almost certainly be subject to planning conditions relating to remediation and validation. Once a specific, preferred development strategy has been decided, Lithos could liaise with local Planning Authority and Warranty Provider and prepare a detailed Remediation Strategy document for approval.

14.2.2 The Remediation Strategy document would include:

- General background information, including site location, site description and a summary of ground investigation data
- An overview of existing constraints on development and the aims of the proposed remediation works
- Specific details of the anticipated site remediation/preparatory works
- Details of site supervision and verification
- A summary of implications for redevelopment

14.2.3 The Remediation Strategy will describe what is required, but not how it is achieved; the appointed Contractor would normally be expected to undertake an Options Appraisal, and then prepare a Method Statement.

14.2.4 The anticipated remediation works are summarised below:

- General site clearance of surface materials and vegetation
- Demolition of buildings
- Break-up of slabs and hardstand
- Post demolition investigation of the ground beneath the former buildings and slabs, and other areas of the site which were inaccessible during this ground investigation
- Crushing of all suitable artificial hard material (i.e. concrete/brick etc)
- Turnover (excavation, screening and replacement in engineered layers, with nominal compaction) of the uppermost 2m to 3m of made ground to enable:
  - Inspection of the made ground
  - Removal of below ground obstructions
  - Preparation of the ground for highway construction

- Backfill of all resultant excavations, with appropriate compaction
- Excavation of up to a maximum depth of 2m beneath proposed adoptable road footprints and controlled re-engineering of selected materials in layers to approximately 650mm below final road levels
- Location and treatment of adit/underground tunnel
- Provision of a minimum 600mm thick cover layer of 'clean' soils plus 150mm "hard dig" layer (or marker layer) in all garden and landscaped areas where made ground remains

14.2.5 The remediation contractor should survey reduced levels during the proposed turnover, prior to the placement of any fill.

14.2.6 Subsoil excavated during the site preparatory works for subsequent use as cover in gardens and landscaped areas, would be best placed during the construction phase; i.e. it should be left in stockpile(s) on completion of the site preparatory works.

14.2.7 A minimum 200mm thickness of suitable granular fill (i.e. a "blanket" of 6F2) could be placed along the line of proposed haul roads to provide a firm and stable running layer for the subsequent construction works.

14.2.8 It is strongly recommended that the demolition contractor should chase-out all significant buried structures, and survey-in the resultant excavations before making them safe by backfilling. At the very least, relevant features should be surveyed-in before "hiding" them beneath a veneer of rubble. Similarly, it would be prudent to complete a drainage survey prior to blading rubble across the site to leave it safe and secure.

14.3 Control of excavation arisings

14.3.1 Excavations into made ground are likely to yield contaminated arisings. The groundworker should carefully segregate (and stockpile separately) made ground arisings from arisings of "clean" natural soils, in order that an excessive volume of unsuitable material is not generated.

14.3.2 The groundworker should appreciate the need for good materials management. Most notably the importance of not mixing different materials within a given stockpile; i.e. there should be separate stockpiles of: topsoil; grubbed-up concrete hardstand; quarry rubble; reworked natural fill, tarmac; excess clean, natural soil arisings; general construction waste etc.

14.3.3 Further characterisation of stockpiled materials is likely to be required if off-site disposal is proposed. See also comments in Section 10.9 regarding asbestos.

14.3.4 Made ground arisings could be:

- Placed in area deliberately left low on completion of the remediation works in order to accommodate construction arisings
- redistributed beneath concrete oversite, or areas of hardstanding, where they would be satisfactorily isolated from end users; only if suitable (i.e. not compressible, rich in deleterious matter etc)
- Isolated beneath the 600mm thick cover layer and 150mm "hard dig" in garden or landscaped areas
- Exported from site to a suitably licensed landfill facility

14.3.5 Natural ground arisings should be suitable for use as subsoil in the proposed soil cover.

14.4 Good practice guidance

14.4.1 The construction phase groundworker should follow good environmental practice to minimise the risks of spillage, leakage etc with reference, but not limited, to the following documents:

- CIRIA C741[14]
- EA Pollution Prevention Guidelines[15]:
  - PPG6 - Working at construction and demolition sites
  - PPG2 - Above ground oil storage tank
  - PPG7 – The safe operation of refuelling facilities.
  - PPG21 – Incident Response Planning

14.4.2 Site preparatory works associated with this project are likely to involve the re-use of both natural and made ground soils on site. Therefore, the Contractor should prepare a Materials Management Plan (MMP) in accordance with the CL:AIRE Code of Practice (v2, March 2011) [16].

14.4.3 The MMP will document how all of the materials to be excavated during the proposed site preparatory and remediation earthworks are to be dealt with.

14.5 New utilities

14.5.1 It is strongly recommended that all statutory service bodies are consulted at an early stage with respect to the ground conditions within which they will lay services in order to enable them to assess at an early stage any potential abnormal costs.

14.5.2 It is recommended that trenches for services including site drainage and water supply are cut over size in order to isolate pipe materials from potential contaminants and to enable maintenance to be conducted in "clean" material.

14.5.3 Water Companies have a statutory duty to supply wholesome water, which could be compromised by the selection of an inappropriate pipe material. For example, compounds such as petroleum hydrocarbons and solvents can permeate commonly used plastics pipes, and/or corrosive chemicals can reduce the service life of metallic pipes. Guidance has been developed for the selection of pipes in brownfield sites and is contained in a UKWIR Report[17].

14.5.4 This site is brownfield, and therefore consideration of soil contaminant concentrations is required. Samples taken must be representative of the soil conditions in which the water pipes are proposed to be laid; normally water pipes are laid 0.7m to 1.3m below finished ground level.

14.5.5 At the time of writing, significant remediation earthworks are anticipated, and ground currently present along proposed supply pipe routes will almost certainly be redistributed. Consequently, to date laboratory testing of soil samples in line with UKWIR guidance has not been undertaken.

[14] *CIRIA C741 (2015) - Environmental Good Practice on Site*
[15] *Whilst this has formally been withdrawn it can still be accessed via the EA archives and provides useful information on managing risks.*
[16] *The Definition of Waste: Development Industry Code of Practice. CL:AIRE, 2011.*
[17] *UKWIR Report 10/WM/03/21 – 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites'.*

14.5.6 However, given the site's size, history, and ground conditions encountered, Yorkshire Water may require sampling within 15m of proposed water supply pipes, once infrastructure design has been completed. In the meantime, it is considered likely that Yorkshire Water will request the use of Protectaline mains, with plastic coated copper house connections, given that residual organic contaminants will still be present post-remediation, albeit at acceptable concentrations.

14.6 Health & safety issues - construction workers

14.6.1 Access into excavations etc. must be controlled and undertaken in accordance with the CDM Regulations 2015, most notably Regulation 22, to mitigate risk of collapse or asphyxiation.

14.6.2 Before site operations are started, the necessary COSHH statements and Health & Safety Plan should be drafted in accordance with the CDM regulations.

14.6.3 The bulk of the made ground will be retained on site. This made ground contains contaminants at concentrations above the guidance threshold values for an end use that includes domestic gardens. Workers involved in excavations for foundations, drainage, utilities etc are likely to come into direct contact with the made ground.

14.6.4 Although workers will only be exposed to the contaminated soil for a relatively short time, the contaminants represent a risk, and simple precautionary measures are required, i.e. good personal hygiene and basic personnel protective equipment.

14.6.5 Consequently, during the remediation and construction phases of the site development it will be necessary to protect the health and safety of site personnel. General guidance on these matters is given in the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Redevelopment of Contaminated Land". In summary, the following measures are suggested to provide a minimum level of protection:

- All ground workers should be issued with protective clothing, footwear and gloves. Personnel should be instructed in why and how they are to be used.
- Hand-washing and boot-washing facilities.
- Care should be taken to minimise the potential for off-site migration of contamination by the provision of dust suppression control and wheel cleaning equipment during the construction works.
- Good practices relating to personal hygiene should be adopted on the site.
- The contractor should satisfy the Health & Safety Executive with regard to any other matters concerning the health, safety and welfare of persons on the site.

14.7 Potential development constraints

14.7.1 Topography will require significant regrade earthworks, most notably in the east where gradients reach approximately 1 in 5.

14.7.2 Deep quarry backfill and differing depths of made ground represent a development constraint. The final layout should consider the location of infilled quarry, with areas of gardens and POS located over the deepest made ground wherever possible to reduce the abnormals associated with piled foundations etc.

14.7.3 Some deterioration of the surface, most notably in **Area A**, is likely to be caused by trafficking, especially after topsoil has been stripped and during/after periods of significant rainfall. Consequently, it would be prudent to consider placement of a minimum 200mm thickness of suitable granular fill (i.e. a "blanket" of 6F2) along the line of proposed highways and any temporary haul roads to protect formation during the construction phase.

14.7.4 The adit present in the north eastern part of site, will likely require further investigation and treatment.

15 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

15.1 General

15.1.1 The site is located off Wakefield Road, approximately 600m southwest of Pontefract town centre, and currently comprises c. 0.8 hectares of overgrown vegetation with some derelict and partially demolished buildings.

15.1.2 The site has remained relatively unchanged throughout history, with a Priory located in the northeast corner and the remainder of site covered by woodland.

15.1.3 it is understood is to be redeveloped with 22 no. traditional 2/3 storey domestic dwellings with associated gardens, POS and adoptable roads and sewers. A proposed layout has been provided.

15.1.4 The site has been subject to quarrying of sandstone and significant depths of quarry backfill underlie approx. half of the proposed area of development.

15.2 Mining & quarrying

15.2.1 This site is underlain at depth Newstead Rock bedrock, and the shallowest coal seams lies at least 400m below the surface. Whilst the site lies within a Coal Authority Low Risk area, no significant risks have been identified, and an intrusive mining investigation will not be required.

15.2.2 Our investigation revealed approx. 50% of the site has been subject to quarrying. This is likely to have been prior to 1852.

15.2.3 Granular Made Ground underlies the majority of the site, to relatively shallow depths in **Area B** (up to 0.3m) and to greater depths in **Area A** (up to 0.9m) particularly in the centre of the site.

15.2.4 Deep Quarry Backfill underlies c. 0.35 ha (40%) of the total site area, comprising predominantly brick, concrete, glass, ceramic and fragments of metal, wood, paper, plastic etc. to varying depth of between 2.0m and 4.0m (maximum >5.8m). The Quarry Backfill is beneath the Granular Made Ground, and underlain by reworked natural material (comprising sand and gravel with cobbles).

15.2.5 Depth of backfill increases from less than 1.0m in the eastern part of the quarry, to around 9.4m in the west (in BH01). This suggests a buried former quarry "ramp" is present, sloping at c. 30 degrees, running broadly north-south between Areas A & B.

15.3 Potential issues associated with deep backfill

15.3.1 It is considered likely that the quarry backfill was placed without mechanical compaction in irregular and thick layers without any screening to remove oversized materials, degradable waste etc. Such material is prone to both ongoing creep, associated with self-weight, and settlement caused by any new loading.

15.3.2 At this stage, it is considered that the presence of deep backfill will have implications for foundations, drainage, new utilities and highways.

15.4 Foundations

15.4.1 The site can be divided into two broad areas in terms of likely foundation requirements for new plots:

- Shallow strips/trench-fill footings in the east (**Area B**) - c. 60% of plots
- Piled foundations in the west (**Area A**) - c. 40% of plots

15.4.2 It is considered that shallow strip or deepened trench fill footings will be the most suitable foundation solution for the majority of two or three storey houses constructed in **Area B** in the eastern half of the site. Footings will be founded in competent Yellow Sands Formation or Newstead Rock. This solution is viable where the made ground is less than about 2.5m thick, and competent rock is the founding material.

15.4.3 Piled foundations will be the likely solution for dwellings constructed in **Area A**, where deeper made ground was encountered.

15.4.4 Piled foundations should extend into the underlying bedrock. The safe working load that may be supported on a pile is dependent on the pile diameter, its founding depth and the method of installation.

15.4.5 Boreholes indicate that competent sandstone bedrock lies at depths of between 4.0m and 9.5m, below current ground levels. Consequently, preliminary estimates for pile lengths will be between 4.0m and 10m

15.4.6 Turnover the full thickness of made ground will not be possible and therefore some boulders may remain at depth. Consequently, some pre-boring or revision of the piling layout is may be required.

15.4.7 There is the potential for settlement of the ground in external areas around piled plots, and consideration should be given to mitigation measures.

15.4.8 Consideration of any alternative foundation solution to piles would require input from specialist geotechnical and structural engineers capable of assessing the risks and designing accordingly. For shallow foundation solutions (e.g. rafts or suitably reinforced strip footings), such assessment is complex.

15.5 Highways

15.5.1 Where made ground is present its full thickness (up to a maximum of 2m from existing ground level or proposed highway formation, whichever is the lower) should be excavated and either replaced with suitable aggregate or be screened to allow selection of suitable material, before being replaced in engineered layers.

15.5.2 Where the made ground is re-engineered it is considered that a CBR value of at least 3% should be achievable. However, this should be verified by field trials.

15.5.3 If any new highway spans a quarry 'high-wall' two layers of Tensar Triax TX160 (or equivalent) geogrid sandwiched within at least 300mm of suitable aggregate should be placed beneath the full width of the highway at least 1.0m below the deepest sewer invert.

15.5.4 A specification will need to be agreed with the adopting authority.

15.6 Contamination & remediation

15.6.1 The made ground has yielded elevated concentrations of a number of metals; most notably lead, copper, arsenic and zinc, as well as elevated organic contaminants in 2 location.

15.6.2 Therefore, the Granular Made Ground and Quarry Backfill should be isolated beneath a 600mm clean cover comprising at least 150mm of Topsoil and 450mm Subsoil over a 150mm hard-dig layer. The proposed cover should sufficiently isolate end users from the contaminants found to date.

15.6.3 It would be prudent to also allow for some excavation and removal/treatment of more grossly contaminated soils during the proposed earthworks.

15.7 Hazardous gas

15.7.1 The site is in an area where 1-3% of homes are estimated to be above the radon action level. Radon protection is not required, but the Developer might consider providing new dwellings with basic measures in light of Public Health England advice.

15.7.2 The site is underlain by deep quarry backfill.

15.7.3 Consequently, a hazardous gas risk assessment is required, along with monitoring of the installed gas monitoring wells. At this stage, in the absence of any monitoring, it would be prudent to assume that Amber 2 protection measures will be required.

15.7.4 If indoor vapour risk is considered potentially significant, a suitable membrane, resistant to degradation when in contact with hydrocarbon vapours will be required for all plots built above, and within 20m of the processed material following placement during the site preparatory works.

15.8 Flooding

15.8.1 The site lies in Flood Zone 1, where the risk of flooding from rivers or the sea is classified as low.

15.9 Drainage

15.9.1 Due to the presence of deep made ground across the majority of the site soakaways will not provide a suitable means of surface water disposal. Consequently, it will be necessary to consider alternative sustainable drainage systems (SUDS), and there may be a need for surface water balancing.

15.9.2 Furthermore, the sloping nature of the site could result in springs being created down-gradient so rendering soakaways unfeasible.

15.9.3 Based on the exploratory hole logs, excavation greater than 2.0m is likely to prove difficult across about 50% of the site. It would therefore be prudent to allow for excavation of hard rock in any deep excavations such as those that may be required for drainage etc.

15.10 Further works

15.10.1 In accordance with BS 8004 and EC7, piling contractors may require rotary cored boreholes extended a minimum 5m into competent bedrock using rotary coring techniques.

15.10.2 Gas monitoring, which should take place a minimum of 6 visits over a 3-month period, subject to the results, additional monitoring may be required.

15.10.3 Further investigation (either intrusive or non-intrusive) is recommended to confirm the full below ground extents of the adit and how it relates to the position of any proposed plots.

15.10.4 Post demolition investigation of the ground beneath the former buildings and slabs, and other areas of the site which were inaccessible during this ground investigation.

15.10.5 Preparation of a Remediation Strategy

Appendix A

General Notes

01 - Environmental setting
Generic notes – geoenvironmental Investigations

General

Third party information obtained from the British Geological Survey (BGS), the Coal Authority, the Local Authority etc is presented in the "Search Responses" Appendix of this Geoenvironmental Report.

Geology, mining & quarrying

In order to establish the geological setting of a site, Lithos refer to BGS maps for the area, and the relevant geological memoir. Further information is sourced by reference to current and historical OS plans.

In July 2011, the Coal Authority (CA) formalised their requirements in relation to planning applications and introduced some new terminology. The CA, using its extensive records has prepared plans for all coalfield Local Planning Authorities, which effectively refines the defined coalfield areas into High Risk and Low Risk areas. **High Risk** areas are likely to be affected by a range of legacy issues that pose a risk to surface stability, including: mine entries; shallow coal workings; workable coal seam outcrops; mines gas; and previous surface mining sites. **Low Risk** areas comprise the remainder of the defined coalfield, and are areas where no known defined risks have been recorded; although there may still be unrecorded issues. Where a site lies within either a High or Low Risk area, a mining report is obtained from the CA.

Landfills

Reference is made to publicly available Government held digital data via **QGIS** (an Open Source Geographic Information System), data from Landmark or Groundsure, and sometimes the Environment Agency and the Local Authority with respect to known areas of landfilling within 250m of the proposed development site.

Historical OS plans are also inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Radon

Radon is a colourless, odourless gas, which is radioactive. It is formed in strata that contain uranium and radium (most notably granite), and can move though fissures eventually discharging to atmosphere, or the spaces under and within buildings. Where radon occurs in high concentrations, it can pose a risk to health.

In order to assess potential risks associated with radon gas, Lithos refer to BRE Report BR211[1], and the Public Health England website. Advice on the limitation of exposure of the population to radon in buildings was originally published in 1990 by the National Radiological Protection Board (NRPB), which joined the Health Protection Agency (HPA) in 2005; the HPA updated NRPB advice in July 2010[2]. The HPA became part of Public Health England in 2013.

The HPA recommended that the NRPB radon Action Level for homes be retained, and a new Target Level for radon in homes be introduced. The values of the Action Level and Target Level, expressed as the annual average radon concentration in the home, are 200 Bqm^{-3} and 100 Bqm^{-3} respectively. The Target Level was to provide an objective for remedial action in existing homes and preventive action in new homes.

The term 'radon Affected Area' is defined as those parts of the country with >1% of homes estimated to be above the Action Levels. The NRPB first indicated which parts of the country should be regarded as radon Affected Areas in 1990. A more detailed mapping method was developed by the HPA in conjunction with the British Geological Survey in 2007[3]. The level of protection needed is site-specific and can be determined by reference to this mapping on the Public Health England website, which indicates the highest radon potential within each 1km grid square. Each 1km grid square is classified on the basis of the percentage of existing homes within that grid square estimated to have radon concentrations above the Action Level. There are 6 'bands': <1%; 1 to 3%; 3 to 5%; 5 to 10%; 10 to 30%; and >30%.

The NRPB advised that action should be taken to reduce radon concentrations in existing homes if the radon concentration exceeded the Action Level of 200 Bqm^{-3} in room air averaged over a year; ten times the average UK domestic radon concentration. NRPB advice informed changes in the requirements for radon protection in new buildings.

- **Basic** preventive measures are required in new buildings, extensions, conversions and refurbishments if the probability of exceeding the Action Level is **>3%** in England and Wales, and >1% in Scotland and Northern Ireland.
- Provision for further preventive (**Full**) measures is required in new buildings if the probability of exceeding the Action Level is **>10%**.

At present Building Regulations Approved Document C advocates basic measures for the probability banding 3% to 10%, and full measures if >10%. However, Public Health England would like to see all new build include basic measures.

Action & Target Levels should also be applied to non-domestic buildings with public occupancy exceeding 2,000 hrs/yr and to all schools.

Hydrogeology

Reference is made to publicly available Government held digital data via QGIS, and Landmark or Groundsure with respect to:

- Groundwater quality
- Recorded pollution incidents
- Licensed groundwater abstractions

From April 2010 the EA's Groundwater Protection Policy uses aquifer designations that are consistent with the Water Framework Directive. These designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply), but also their role in supporting surface water flows and wetland ecosystems. The aquifer designation data is based on geological mapping provided by the British Geological Survey. The maps are split into two different types of aquifer designation:

- Superficial (Drift) - permeable unconsolidated (loose) deposits. For example, sands and gravels
- Bedrock - solid permeable formations e.g. sandstone, chalk and limestone

The maps display the following aquifer designations:

Principal aquifers: These are layers of rock or superficial deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

Secondary aquifers: These include a wide range of rock layers or superficial deposits with an equally wide range of water permeability and storage. Secondary aquifers are subdivided into three types:

- **Secondary A** - 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
- **Secondary B** - 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
- Secondary undifferentiated - In most cases, this is because the rock type in question has previously been designated as both a minor and non-aquifer in different locations due to the variable characteristics.

[1] BRE Report BR211, 2015: "Radon: guidance on protective measures for new buildings.

[2] Limitation of Human Exposure to Radon, Documents of the Health Protection Agency - Radiation, Chemical and Environmental Hazards, RCE-15. July 2010.

[3] Miles JCH, Appleton JD, Rees DM, Green BMR, Adlam KAM and Myers AH (2007). Indicative Atlas of Radon in England and Wales. Chilton, HPA-RPD-033.

Unproductive strata: These are rock layers or superficial deposits with low permeability that have negligible significance for water supply or river base flow.

The EA maps only display the principal and secondary aquifers as coloured areas. All uncoloured areas on the map will be unproductive strata. However, for uncoloured areas on the superficial (drift) designation map it is not possible to distinguish between areas of unproductive strata and areas where no superficial deposits are present; to do this, it is necessary to consult the published geological survey maps.

For the purposes of the EA's Groundwater Protection Policy the following default position applies, unless there is site specific information to the contrary:

- If no superficial (drift) aquifers are shown, the bedrock designation is adopted
- In areas where the bedrock designation shows unproductive strata (the uncoloured areas) the superficial designation is adopted
- In all other areas, the more sensitive of the two designations is used (e.g. If secondary superficial overlies principal bedrock, an overall designation of principal is assumed)

The EA have also designated groundwater Source Protection Zones, which are based on proximity to a groundwater source (springs, wells and abstraction boreholes). The size of a Source Protection Zone is a function of the aquifer, volume of groundwater abstracted and the effective rainfall, and may vary from tens to several thousand hectares.

Hydrology

Reference is made to publicly available Government held digital data via QGIS, and Landmark or Groundsure with respect to:

- Surface water quality
- Recorded pollution incidents
- Licensed abstractions (groundwater & surface waters)
- Licensed discharge consents
- Site susceptibility to flooding

The EA have set **water quality** targets for all rivers. These targets are known as River Quality Objectives (RQOs). The water quality classification scheme used to set RQO planning targets is known as the River Ecosystem scheme. The scheme comprises five classes (RE1 to RE5) which reflect the chemical quality requirements of communities of plants and animals occurring in our rivers.

General Quality Assessment (GQA) grades reflect actual water quality. They are based on the most recent analytical testing undertaken by the EA. There are 6 GQA grades (denoted A to F) defined by the concentrations of biochemical oxygen demand, total ammonia and dissolved oxygen.

The susceptibility of a site to **flooding** is assessed by reference to a Flood Map on the Environment Agency's website. These maps show natural floodplains - areas potentially at risk of flooding if a river rises above its banks, or high tides and stormy seas cause flooding in coastal areas. There are two different kinds of area shown on the Flood Map:

1. Dark blue areas (Flood Zone 3) could be flooded by the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year, or by a river by a flood that has a 1% (1 in 100) or greater chance of happening each year
2. Light blue areas (Flood Zone 2) show the additional extent of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1% (1 in 1000) chance of occurring each year

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Where there is no blue shading (Flood Zone 1), there is less than a 0.1% (1 in 1000) chance of flooding occurring each year.

The maps also show all flood defences built in the last five years to protect against river floods with a 1% (1 in 100) chance of happening each year, or floods from the sea with a 0.5% (1 in 200) chance of happening each year, together with some, but not all, older defences and defences which protect against smaller floods.

The Agency's assessment of the likelihood of flooding from rivers and the sea at any location is based on the presence and effect of all flood defences, predicted flood levels, and ground levels.

It should also be noted that as the floodplain shown is the 1 in 100 year, areas outside this may be flooded by more extreme floods (e.g. the 1 in 1000 year flood). Also, parts of the areas shown at risk of flooding will be flooded by lesser floods (e.g. the 1 in 5 year flood). In some places due to the shape of the river valley, the smaller floods will flood a very similar extent to larger floods but to a lesser depth.

If a site falls within a floodplain, it is recommended that a flood survey be undertaken by a specialist who can advise on appropriate mitigating measures; i.e. raising slab levels, provision of storage etc. In accordance with Chapter 10 of the National Planning Policy Framework, a site-specific flood risk assessment is required for: proposals of 1 hectare or greater in Flood Zone 1, or in an area within Flood Zone 1 which has critical drainage problems (as notified to the local planning authority by the Environment Agency); and any new development in Flood Zones 2 and 3.

COMAH & explosive sites

Lithos obtain information from Landmark or Groundsure with respect to Control of Major Accident Hazards (COMAH) or explosive sites within 1km of the proposed development site. Lithos' report refers to any that are present, and recommends that the Client seeks further advice from the HSE.

Areas around COMAH sites (chemical plants etc) are zoned with respect to the implementation of emergency plans. The HSE are a statutory consultee to the local planning authority for all COMAH sites. The COMAH site may have to revise its emergency action plan if development occurs. This might be quite straightforward or could entail significant expenditure. Consequently, the COMAH site may object to a proposed development (although it is the Local Authority who have final say, and they are likely to place more weight on advice from the HSE).

Preliminary conceptual site model

The site's environmental setting (and proposed end use) is used by Lithos to assess the significance of any contamination encountered during the subsequent ground investigation.

Assessment of contaminated land is based on an evaluation of pollutant linkages (source-pathway-receptor). Contaminants within the near surface strata represent a potential source of pollution. The environment (most notably groundwater), site workers and end users are potential receptors.

Potential pollutant linkages are shown on a preliminary conceptual site model (pCSM). A CSM is essentially a cross-section through a site that reflects both the surface topography and underlying geology, and shows surface features of interest. The most significant sources of contamination are then superimposed onto this cross-section together with potential receptors (human health & controlled waters), and plausible pathways between the two. In addition to environmental issues, the CSM should also highlight geotechnical issues.

A pCSM is prepared after consideration of all available "desk study" data, and before design of the ground investigation. Data reviewed should include historical plans (with superimposition on a current-day plan), previous SI reports, geological maps etc. The pCSM, in conjunction with knowledge of site constraints (buildings, services, slopes etc) is used to design the ground investigation.

The revised CSM takes account of data obtained during the ground investigation, including the distribution of made ground, the nature and distribution of contamination etc.

02 - Ground investigation fieldwork
Generic notes – geoenvironmental investigations

General

Lithos Ground Investigations are undertaken in accordance with current UK guidance including:

- BS5930:2015 "Code of practice for site investigation"
- Eurocode 7: BS EN 1997-1:2004. Geotechnical design - Part 1: General rules
- Eurocode 7: BS EN 1997-2:2007. Geotechnical design - Part 2: Ground investigation and testing
- BS10175:2013 "Code of practice for the identification of potentially contaminated sites"
- "Technical Aspects of Site Investigation" – EA R&D Technical Report P5-065/TR (2000)
- "Development of appropriate soil sampling strategies for land contamination" – EA R&D Technical Report P5-066/TR (2001)
- Contaminated Land Reports 1 to 6, most notably CLR Report No. 4 "Sampling strategies for contaminated land"
- "Guidance on the protection of housing on contaminated land" – NHBC & EA R&D Publication 66 (2000)
- AGS: 1996 "Guide to the selection of Geotechnical Soil Laboratory Testing"

Exploratory hole locations

Exploratory hole locations are selected by Lithos, prior to commencement of fieldwork, to provide a representative view of the strata beneath the site and to target potential contaminant sources identified during the preliminary investigation (desk study). Additional exploratory locations are often determined by the site engineer in light of the ground conditions actually encountered; this enables better delineation of the depth and lateral extent of organic contamination, poor ground, relict structures etc.

Investigation techniques

Ground conditions can be investigated by a number of techniques; the procedures used are in general accordance with BS5930: 2015 and BS1377: 1990. Techniques most commonly used by Lithos include:

- Machine excavated **trial pits**, usually equipped with a backactor and a 0.6m wide bucket. Allows a thorough inspection of the ground; especially the uppermost 1m or so (but able to reach depths of up to c. 4m), with the recovery of representative, disturbed samples. Also used to conduct soakaway testing.
- **Window or windowless** sampling boreholes (**dynamic sampling**). Constraints associated with existing buildings, operations and underground service runs can render some sites partly or wholly inaccessible to a mechanical excavator. In such circumstances, window sampling is often the most appropriate technique. A window sampling drilling rig can be manoeuvred in areas of restricted access and results in minimal disturbance of the ground (a 150mm diameter tarmac/concrete core can be lifted and put to one side). However, it should be noted that window sampling allows only a limited inspection of the ground (especially made ground with a significant proportion of coarse material).
- **Cable percussive** (Shell & Auger) boreholes, typically using 150mm diameter tools and casing. Enables the recovery of soil samples and data from greater depth than is possible via trial pitting or a mini-percussive drill rig. Also enables the installation of better/deeper monitoring wells (cf use of a mini-percussive drill rig) due to the utilisation of temporary steel casing during drilling.
- **Rotary percussive** open-hole probeholes are typically drilled using a tri-cone rock roller or polycrystalline diamond compact (PDC) bit with air as the flushing medium. Probeholes are generally lined through made ground with temporary steel casing to prevent hole collapse. Often used to penetrate bedrock to investigate abandoned shallow mineworkings
- **Rotary cored** boreholes. A rock core is cut by a bit, passes up into the inner barrel and, at the end of the coring run, the core barrel assembly is lifted to the surface. Core drilling is relatively expensive, but essential if quality data is required to assess issues associated with deep excavation, rock slope stability etc.

Where installed, gas\groundwater monitoring **wells** typically comprise a lower slotted section, surrounded by a filter pack of 10 mm non-calcareous gravel and an upper plain section surrounded in part by a bentonite seal and in part by gravel or arisings. The top of the plain pipe is cut off below ground level and the monitoring well protected by a square, stopcock type manhole cover set in concrete, or the plain pipe is cut off just above ground level and the well protected by 100mm diameter steel borehole helmet set in concrete. Monitoring well details, including the location of the response zone and bentonite seal are presented on the relevant exploratory hole logs.

In-situ testing

Relative densities of granular materials given on the trial pit logs are based on visual inspection only, they do not relate to any specific bearing capacities.

The relative densities of granular materials encountered in cable percussive boreholes are based on Standard Penetration Test (SPT) results. SPTs are carried out boreholes, in accordance with BS 1377 1990, Part 9 Section 3.3. Where full penetration (600mm) is not possible, N values are calculated by linear extrapolation and are shown on the logs as N* = x. The strength of cohesive deposits is determined using a hand shear vane.

Shear strength test results (hand vane readings) reported on trial pit logs are considered to be more reliable than those reported on window sample logs. Significant sample disturbance occurs during window sampling and consequently shear strength results on disturbed window samples are generally lower than results obtained during trial pitting, in-situ or in large excavated blocks.

Sampling

Typically Lithos collect at least three soil samples from each exploratory hole, although in practice a greater number are often taken. The collection of a sufficient number of samples provides a sound basis upon which to schedule laboratory analysis, ensuring:

- A sufficient number of samples from each (common) site material are tested
- Horizontal and vertical coverage of the site is adequate, thereby providing a robust data set for use in the conceptual ground model
- Any localised, significant, but non-pervasive conditions are considered

Made ground and natural soils encountered in the field during a ground investigation often contain a significant proportion of coarse grained material (e.g. brick etc). Soil samples obtained during most investigations are often only truly representative of the in-situ soil mass where there is an absence of particles coarser than medium gravel; i.e the entire soil mass would pass a 20mm sieve.

Representative bulk samples of the **soil mass** are retrieved from coarse soils for specific geotechnical tests (most notably grading and compaction); this typically requires the collection of at least 10kg of soil, and occasionally >50kg. However, in the context of assessing land contamination, it is generally accepted that samples should be representative of the **soil matrix** of the stratum from which they are taken. Consequently, truly representative samples of coarse soils for subsequent contaminant analysis are not obtained - only the finer fraction is placed in sample containers. Coarse constituents not sampled would typically comprise any 'particles' with an average diameter greater than about 20mm (i.e. coarse gravel, cobble and boulder).

At present, neither ISO/IEC 17025 nor MCERTS specify sample pre-treatment with respect to stone removal. Unsurprisingly therefore UKAS accredited testing laboratories do not adopt the same approach to stones[1] – some crush and test the "as received" soil, whilst others sieve out stones and analyse only the residual soil (the sieve size used varies depending on the laboratory).

In essence, samples taken from coarser soils for contaminant analysis are "screened" by the geoenvironmental engineer in the field, and often sieved again by the laboratory during sample preparation. Geoenvironmental engineers do not typically re-calculate soil mass contaminant concentrations by taking account of the unsampled coarse fraction. Likewise, laboratories that remove stones typically report contaminant concentrations based on the dry weight of soil passing the sieve. In the context of land contamination and human health risk assessment, this is considered reasonable, because it is the soil matrix which is of greatest concern. Stones are unlikely to:

- Provide a significant source for plant uptake (consumption of vegetables)
- Remain on vegetables after washing (consumption of vegetables)
- Be eaten (accidentally by an adult, or deliberately by a child)
- Be whipped-up by the wind for dust generation (inhalation)
- Stick to the skin for any length of time (dermal contact)
- Yield toxic vapour (inhalation)

Consequently, Lithos instruct labs to remove all stones >10mm, and to report the results as dry-weight based on the mass of matrix tested. However, the laboratory are given site-specific instruction where coarse stones are coated in say oil, or impregnated with mobile contaminants such as diesel. Where the stones are predominantly natural, or inert (e.g. brick, concrete etc), removal will clearly result in higher reported concentrations, than if the stones were crushed and added to the matrix.

Where the stones include a significant proportion of contaminant-rich material (e.g. slag, fragments of galvanised metal etc) an argument could be made for crushing and analysing. However, provided the stones are stable (i.e. unlikely to disintegrate or degrade) they should not pose a significant risk to human health for the reasons stated above.

Sometimes it is necessary to obtain samples that are not representative of the wider soil matrix, for example when investigating localised, significant, but non-pervasive conditions. Any such unrepresentative samples are annotated with the suffix '*' (eg 2D*, or 4G*). Lithos' site engineer describes both the unrepresentative sample, and the soil mass from which it was been taken.

Sample Containers (for contaminant analysis). Samples of soil for contaminant testing are placed into appropriate containers (see below). Soil samples for organic analysis are stored in cool boxes, at a temperature of approximately 4ºC, until delivery to the selected laboratory.

Anticipated testing	Container(s)
Asbestos identification	1000ml plastic tub
pH & metals	1000ml plastic tub or 250ml glass jars
non-volatile organics	250ml glass jars
Speciated TPH	250ml & 50ml glass jars
VOCs (incl. naphthalene and\or GRO)	50ml glass jar

Sample Containers (for geotechnical analysis). The majority of samples are only scheduled for PI and sulphate testing, for which 500g of sample is required (a full 0.5-litre plastic tub). However, bulk bags are taken where scheduling of compaction or grading tests is proposed.

Groundwater

Where encountered during fieldwork, groundwater is recorded on exploratory hole logs. If monitoring wells are installed, groundwater levels are also recorded on one or more occasions after completion of the fieldwork. Long-term monitoring of standpipes or piezometers is always recommended if water levels are likely to have a significant effect on earthworks or foundation design.

It should be borne in mind that the rapid excavation rates used during a ground investigation may not allow the establishment of equilibrium water levels. Water levels are likely to fluctuate with season/rainfall and could be substantially higher at wetter times of the year than those found during this investigation.

Description of strata

Soils encountered during a Lithos investigation are described (logged) in general accordance with BS 5930:2015. The descriptions and depth of strata encountered are presented on the exploratory hole logs and summarised in the Ground Conditions section within the main body of text. The materials encountered in the trial pits are logged, samples taken, and tests performed on the in-situ materials in the excavation faces, to depths of up to 1.2m; below this depth these operations are conducted at the surface on disturbed samples recovered from the excavation.

[1] *Mark Perrin. Stoned – Sample Preparation for Soils Analysis. Ground Engineering, April 2007.*

03 – Geotechnical laboratory testing
Generic notes – geoenvironmental investigations

General

Soil samples are delivered to the laboratory for testing along with a schedule of testing drawn up by Lithos. All tests are carried out in accordance with BS 1377:1990. The following laboratory testing is routinely carried out on a selection of samples:

- Atterberg limits & moisture contents
- Soluble sulphate & pH

Where soft, cohesive soils are encountered, one-dimensional consolidation tests are scheduled in order to assess settlement characteristics, and unconsolidated undrained triaxial compression tests to assess shear strength.

The additional tests are typically only scheduled where significant earthworks regrade is anticipated:

- Grading
- Compaction tests
- Particle density

Test results are presented as received in an Appendix to the Geoenvironmental Report.

Atterberg limits & moisture content

The Liquid and Plastic Limits of samples of natural in-situ clay are determined using the cone penetrometer method and the rolling thread test. These tests enable determination of an average Plasticity Index (PI) for each "type" of clay, although judgement is applied where variable results are reported.

PI can be related to shrinkability (low, medium or high) and then to minimum founding depth. Lithos typically only consider a soil to be shrinkable if the proportion finer than 63µm is >35%. PI results are compared against guidance given in the NHBC Standards, Chapter 4.2 (revised April 2003), which advocates the use of modified Plasticity Index (I'p), defined as:

I'p = Ip * (%< 425µm/100)

i.e. if PI is 30%, but the soil contains 80% < 425µm, then: I'p = 30 * 80/100 = 24%.

It should be noted that in accordance with the requirements of BS 1377, the % passing the 425µm sieve is routinely reported by testing labs. Lithos apply engineering judgment where PI results are spread over a range of classifications. Consideration is given to:

- The average values for each particular soil type (ie differentiate between residual soil and alluvium)
- The number of results in each class and
- The actual values

Unless the judgment strongly indicates otherwise, Lithos typically adopts a conservative approach and recommends assumption of the higher classification.

Soluble sulphate and pH

Sulphates in soil and groundwater are the chemical agents most likely to attack sub-surface concrete, resulting in expansion and softening of the concrete to a mush. Another common cause of concrete deterioration is groundwater acidity.

The rate of chemical attack depends on the concentration of aggressive ions and their replenishment at the reaction surface. The rate of replenishment is related to the presence and mobility of groundwater.

Lithos refer to BRE Special Digest 1 (SD1) "Concrete in aggressive ground. Part 1: Assessing the aggressive chemical environment" (2005). SD 1 provides definitions of:

- The nature of the site (greenfield, brownfield or pyritic)
- The groundwater regime (static, mobile or highly mobile)
- The design sulphate class (DS class) and
- The aggressive chemical environment for concrete (ACEC class)

Lithos reports clearly state each of the above for the site being considered.

The concentrations of sulphate in aqueous soil/fill extracts are determined in the laboratory using the gravimetric method. The results are expressed in terms of SO_4 for direct comparison with BS 5328:1997. The pH value of each sample was determined by the electrometric method.

SD1 also discusses determination of "representative" sulphate concentration from a number of tests. Essentially if <10 samples of a given soil-type have been tested, the highest measured sulphate concentration should be taken. If >10 samples have been tested, the mean of the highest 20% of the sulphate test results can be taken. With respect to groundwater, the highest sulphate concentration should always be taken.

With respect to pH (soil & groundwater) the value used is the lowest value if <10 samples have been tested and the mean of the lowest 20% if >10 samples have been tested.

Oedometer (Consolidation) tests

Oedometer tests measure a soil's consolidation properties, and are performed by applying different loads to a soil sample and measuring the deformation response. Typically the sample is subject to 5 incremental pressures (4 loading & 1 unloading), and the convention is for each subsequent pressure to be double the previous pressure. BS1377 suggests the **initial** pressure should be:

a) For stiff soils the effective overburden pressure*
b) For firm soils "somewhat less" than the effective overburden pressure
c) For soft soils "appreciably less" than the effective overburden pressure, usually 25 kPa or less
d) For very soft soils very low, typically 5 kPa or 10 kPa

* Effective **overburden pressure** (kNm^{-2}) = depth (m) x soil bulk unit weight (kNm^{-3})

Results from these tests are used to predict how a soil in the field will deform in response to a change in effective stress.

Triaxial tests

This test measures the mechanical properties of a soil by placing the sample between two parallel platens which apply stress in one (usually vertical) direction, with fluid used to apply a confining pressure in the perpendicular directions. During the test, the surrounding fluid is pressurized, and then stress on the platens is increased until the material in the cylinder fails.

From triaxial test data, it is possible to extract fundamental material parameters, including its angle of shearing resistance, apparent cohesion, and dilatancy angle. These parameters are then used in computer models to predict how the material will behave in a larger-scale engineering application.

Quick (single stage, Unconsolidated, Undrained tests) are most appropriate for foundation design. This is because load is applied relatively quickly, and shear strength of the clay will be lowest initially; after the applied load causes some consolidation of the ground (after drainage results in dissipation of short-term excess pore water pressure), the in-situ clays will become progressively stronger and hence the factor of safety will increase. Confining pressure is specified as equivalent to overburden pressure (kNm^{-2}).

Foundations on granular soils would use effective shear strength parameters (c' and phi') to assess safe bearing capacity, as the soil would fully drain quickly. These effective shear strength parameters could be determined from Consolidated Undrained (or sometimes the more expensive Consolidated Drained) triaxial tests, but often correlations to the SPT are used.

Unconsolidated Undrained triaxial tests are most appropriate for assessment of the stability of fill slopes on clays. Similar to foundations, the application of load gradually increases the strength of the clays and hence the critical case is the short term undrained condition.

Consolidated Undrained (or sometimes **Consolidated Drained**) triaxial tests are most appropriate for assessment of the stability of cut slopes in clays. This is because unloading of the ground leads to short term reduction in pore pressures that approximately balance the unloading, hence the soil strength is largely unchanged. Over time the reduced pore pressures suck water in, which leads in to the progressive increase in pore pressure and loss of strength. The fully drained state is critical, which must be modelled using effective strength parameters and a reasonable estimate of the long term water table conditions.

Slopes formed in granular soils would use effective shear strength parameters (c' and phi') to assess safe bearing capacity, as the soil would fully drain quickly. These effective shear strength parameters could be determined from Consolidated Undrained (or sometimes the more expensive Consolidated Drained) triaxial tests, but often correlations to the SPT are used.

Determination of analytical suite

An assessment of potential contaminants associated with the former usages of the site is undertaken with reference to CLR 8 "Potential contaminants for the assessment of land" and the relevant DETR Industry Profile(s).

Common contaminants

Common **Inorganic** Contaminants include:

- Metals, most notably cadmium, copper, chromium, mercury, lead, nickel, and zinc
- Semi-metals, most notably arsenic, selenium, and (water soluble) boron
- Non-metals, most notably sulphur
- Inorganic anions, most notably cyanides (free & complex), sulphates, sulphides, and nitrates

With respect to the terminology used by most analytical laboratories:

Total cyanide = Free cyanide + Complex cyanide

Total cyanide (CN) is determined by acid extraction; whereas free cyanide is the water soluble fraction. Complex cyanide is "bound" in compounds and is hard to breakdown. Laboratory determination of complex CN involves subjecting the sample to UV digestion for determination of both free and total CN.

Thiocyanate (SCN) is a different species combined with sulphur.

Elemental sulphur (S) and free sulphur are the same. Total sulphur is all forms, including that present in sulphates (SO_4), sulphides etc.

There are 2 forms of chromium (Cr), chromium VI and chromium III. Chromium VI is the more toxic of these. In soils, total chromium is determined by a strong aqua regia acid digestion. Chromium VI is an empirical method based on a water extract test.

Common **Organic** Contaminants include hydrocarbons, phenols, and polychlorinated biphenyls.

Petroleum is a mixture of hydrocarbons produced from the distillation of crude oil, and includes aliphatics (alkanes, alkenes and cycloalkanes), aromatics (benzene and derivatives) and hydrocarbon-like compounds containing minor amounts of oxygen, sulphur or nitrogen. Petroleum hydrocarbons can be grouped based on the carbon number range:

- GRO – Gasoline Range Organics (typically C_6 to C_{10}). Also referred to as PRO – Petroleum Range Organics
- DRO – Diesel Range Organics (typically C_{10} to C_{28})
- LRO - Lubricating Oil Range Organics (typically C_{28} to C_{40})
- MRO – Mineral Oil Range Organics (typically C_{18} to C_{44})

However, it should be borne in mind that the terms "GRO" and "DRO" analysis are purely descriptive terms, the exact definition of which varies. Total Petroleum Hydrocarbons (TPH) is also a poorly defined term; some testing laboratories regard TPH as hydrocarbons ranging from C_5-C_{40}, whereas others define TPH as C_{10}-C_{30}.

The composition of a TPH plume migrating through the ground can vary significantly; this is primarily dictated by the nature of the source (e.g. petrol, diesel, engine oil etc). Furthermore, different hydrocarbons are affected differently by weathering processes, and this can result in further variation in the chemical composition of the TPH.

Gasoline contains light aliphatic hydrocarbons (especially within the C_4 to C_5 range) that are volatile. The aromatic hydrocarbons in gasoline are primarily benzene, toluene, ethylbenzene and xylenes, referred to as BTEX. Small amounts of polycyclic aromatic hydrocarbons (PAHs) such as benzo(a)pyrene may also be present. Diesel and light fuel oils have higher molecular weights than gasoline. Consequently, they are less volatile and less water soluble. About 25 to 35% is composed of aromatic hydrocarbons. BTEX concentrations are generally low.

Heavy Fuel Oils are typically dark in colour and considerably more viscous than water. They contain 15 to 40% aromatic hydrocarbons. Polar nitrogen, sulphur and oxygen-containing compounds (NSO) compounds are also present. Lubricating Oils are relatively viscous and insoluble in groundwater. They may contain 10 to 30% aromatics, including the heavier PAHs. NSO compounds are also common.

Polycyclic Aromatic Hydrocarbons (PAHs) have more than two fused benzene rings as a structural characteristic. PAH compounds are present in both petrol and diesel, although in significantly lower concentrations than in coal tars. Certain PAH compounds are carcinogenic (benzo(a)pyrene) and\or mobile in the environment (naphthalene).

Volatile Organic Compounds (VOCs) are organic chemicals, and most are liquids that readily evaporate on exposure to air. Examples include benzene, toluene, xylene, chloroform etc. Semi-Volatile Organic Compounds (sVOCs) include phenol and benzo(a)pyrene, and have relatively low boiling points. Both groups of chemicals are readily absorbed through skin and some, such as benzene, are believed to be linked to tumour growth.

Phenols are compounds that have a hydroxyl group (-OH) attached to an aromatic ring (ie include a benzene ring and an –OH group). Most are colourless solids. A solution of phenol in water is known as carbolic acid, and is a powerful antiseptic. However, phenol vapour is toxic, and skin contact can result in burns.

Polychlorinated Biphenyls (PCBs) were used in pre-1974 transformers as dielectric fluids. PCB's are of increasing toxicity relative to the degree of chlorination. Acute symptoms of PCB poisoning are irritation of the respiratory tract leading to coughing and shortness of breath. Nausea, vomiting and abdominal pain are caused by ingestion of PCB's.

Dioxins and furans (polychlorinated dibenzodioxins and polychlorinated dibenzofurans) are some of the most toxic chemicals known; in the environment, they tend to bio-accumulate in the food chain. Dioxin is a general term that describes a group of hundreds of chemicals that are highly persistent in the environment. The most toxic compound is 2,3,7,8-tetrachlorodibenzo-p-dioxin or TCDD.

Dioxin is formed by burning chlorine-based chemical compounds with hydrocarbons. The major source of dioxin in the environment comes from waste-burning incinerators and also from backyard burn-barrels. Dioxin pollution is also affiliated with paper mills which use chlorine bleaching in their process and with the production of Polyvinyl Chloride (PVC) plastics and with the production of certain chlorinated chemicals (like many pesticides).

Methods of analysis (organic compounds)

TPH by GC-FID is an analytical technique which only detects hydrocarbons (aliphatic and aromatic) in the range C_{10} to C_{40} (volatiles, heavy tars, humic material and sulphur are not detected). The laboratory can provide a broad, 'banded' breakdown of the TPH results into gasoline range organics (GRO), diesel range organics (DRO) and heavier lubricating oil range organics (LRO), or fully speciated results with the reporting of hydrocarbon concentrations in 14 specific carbon bandings based upon behavioural characteristics, e.g. aliphatic C_6 to C_8, aromatic C_{10} to C_{12} etc.

Speciated VOC (by GC-MS) analysis quantifies the concentrations of 30 USA-EPA priority compounds. These include chlorinated alkanes and alkenes (in the molecular weight range chloroethane to tetrachloroethane); trimethylbenzenes; dichlorobenzenes; and the 4 BTEX compounds (benzene, ethyl-benzene, toluene & xylene).

Speciated sVOC by (GC-MS) analysis quantifies the concentrations of a variety of organic compounds, including the 16 USA-EPA priority PAHs, phenols, 7 USA EPA priority PCB congeners, herbicides & pesticides.

Note: PAHs are hydrocarbons and consequently (where present) will be picked-up when scheduling TPH by GC-FID.

Note: Risk assessment models require physiochemical properties (solubilities, toxicities etc) of compounds in order to model their behaviour in the environment. These physiochemical properties cannot be derived from a single "TPH", "GRO" or "DRO" value. However, the carbon banded fractions can be used in risk assessment models.

Current UK guidance

The UK approach to contaminated land is set out in Contaminated Land Report No. 11 (2004) "Model Procedures for the Management of Land Contamination". The approach is based upon risk assessment, where risk is defined as the combination of the probability of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.

In the context of land contamination, there are three essential elements to any risk: (1) a contaminant source; (2) a receptor (eg controlled water or people); and (3) a pathway linking (1) and (2). Risk can only exist where all three elements combine to create a pollutant linkage. Risk assessment requires the formulation of a conceptual model which supports the identification and assessment of pollutant linkages.

Lithos adopt a tiered approach to risk assessment, consistent with UK guidance and best practice. The initial step of such a risk assessment (or Tier 1) is the comparison of site data with appropriate UK guidance levels, Lithos risk-derived screening values, or remedial targets. It should be noted that exceedance of Tier 1 does not necessarily mean that remedial action will be required.

Soil screening values used by Lithos

In March 2002 DEFRA and the Environment Agency published a series of technical papers (R&D Publications CLR 7, 8, 9 and 10) outlining the UK approach to the assessment of risk to human health from land contamination. In 2008 CLR 7, 9 and 10 and all corresponding SGV and Tox reports were withdrawn and superseded by new guidance including:

- Guidance on Comparing Soil Contamination Data with a Critical Concentration - CL:AIRE and CIEH, May 2008
- Evaluation of models for predicting plant uptake of chemicals from soil - Science Report – SC050021/SR
- Human health toxicological assessment of contaminants in soil - Science Report: SC050021/SR2
- Updated technical background to the CLEA model - Science Report: SC050021/SR3
- CLEA Software Handbook (Version 1.071), Science report: SC050021/SR4
- Compilation of data for priority organic pollutants for derivation of Soil Guideline Values - Science Report: SC050021/SR7

The approach set out in these documents represents current scientific knowledge and thinking; and includes the Contaminated Land Exposure Model (CLEAv1.06). The Environment Agency are in the process of using this updated approach to regenerate a selection of Soil Guideline Values (SGVs).

CLEA SGVs were derived for standard land use scenarios predominantly in the context of Part IIA, using a conceptual site model (CSM) defined in SR3. Lithos have incorporated amendments to the CSM used to derive SGVs, that more accurately reflect redevelopment within the planning regime; consequently, Lithos have not adopted any published SGV as a screening value.

The CLEA conceptual site model assumes a source located in a sandy loam, with 6% soil organic matter (SOM) - equivalent to 3.5% total organic carbon (TOC). However, where the average TOC value for a particular soil type is significantly lower than the 3.5%, evaluation of Lithos Screening Values should be undertaken and a site specific risk assessment will usually be required. Other CLEA default characteristics adopted by Lithos are:

Sandy Loam characteristics (source)	Default values adopted
Total porosity (fraction)	0.53
Water filled porosity (fraction)	0.33
Air filled porosity (fraction)	0.2

Lithos have derived Screening Values for four different CSMs (scenarios); these are:

A - Residential with gardens, but no cover (or only up to 300mm)

B - Residential with gardens and 600mm 'clean' cover

C - Residential apartments with landscaping (i.e. no home grown produce)

D - Commercial/industrial with landscaping

E – Importation of soil cover

The **exposure** pathways considered for each scenario are detailed in the table below.

Scenario	Land use	Pathways	Justification
A	Residential with garden, but no cover (or only up to 300mm)	• Direct ingestion of soil • Dermal contact • Consumption of vegetables & soil attached to vegetables • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	Minimal cover – insufficient to break any pathways therefore all exposure pathways are relevant.
B	Residential with garden minimum 600mm cover	• Inhalation of indoor vapours • Inhalation of outdoor vapours	The 600mm cover removes the risk from all pathways other than inhalation.
C	Residential apartments with landscaped areas and minimum 300mm cover	• Direct ingestion of soil • Dermal contact • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	All pathways applicable due to possible exposure from landscaped areas. However consumption of home grown produce not included as unlikely to be grown in landscaped areas. Where vegetables are to be grown site specific QRA may be required.
D	Commercial/ industrial with landscaped areas no cover	• Direct ingestion of soil • Dermal contact • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	All pathways applicable due to possible exposure from landscaped areas. Assumed the commercial development consists of offices to provide a conservative assessment.
E	Importation of soil for cover in garden and landscaped areas	• Direct ingestion of soil • Dermal contact • Consumption of vegetables & soil attached to vegetables • Inhalation of outdoor vapours and dust	Material used as cover to break existing pathways therefore all direct and indirect pathways relevant; however cover is **not** placed below plots therefore indoor inhalation is not relevant.

Lithos have assumed the source of contamination is directly below the building foundations; i.e. a depth to source of 0.15m as opposed to the CLEA default of 0.65m. This assumption provides for a more conservative approach than the UK default. This adjustment has been included to account for sites where made ground is re-engineered to enable new buildings to be established on raft foundations. In such situations contamination may lie directly beneath the foundation.

The Soil Screening Values referred to in this document are **not** intended to be used when considering potential risks associated with:

- Existing land uses in the context of Part IIA of the Environment Protection Act 1990;
- End uses such as allotments, sports fields, children's playgrounds, care homes, hospitals etc; and
- Controlled waters.

In December 2013 Defra published the results of research project SP1010 – Development of Category 4 Screening Levels (C4SLs) for Assessment of Land Affected by Contamination. The objective of this project was to provide technical guidance in support of Defra's revised Statutory Guidance for Part 2A of the Environmental Protection Act 1990 (Part 2A). The revised Statutory Guidance, published in April 2012, introduced a new four-category system for classifying land under Part 2A where Category 1 includes land where the level of risk is clearly unacceptable, and Category 4 includes land where the level of risk posed is acceptably low. Project SP1010 aimed to deliver:

- A methodology for deriving C4SLs for four generic land-uses comprising residential, commercial, allotments and public open space; and
- Demonstration of the methodology, via derivation of C4SLs for 6 substances – arsenic, cadmium, chromium IV, lead, benzene & benzo(a)pyrene.

The methodology for deriving both the previous Soil Guideline Values and the new Category 4 Screening Levels is based on the Environment Agency's Contaminated Land Exposure Assessment (CLEA) methodology. Development of C4SLs has been achieved by modifying the toxicological and\or exposure parameters used within CLEA (while maintaining current exposure parameters).

The Part 2A Statutory Guidance was developed on the basis that C4SLs could be used under the planning regime. However, policy responsibility for the National Planning Policy Framework falls to the Department for Communities and Local Government. Defra anticipate that, where they exist, C4SLs will be used as generic screening criteria, and Lithos consider C4SLs to be suitable for use as Tier 1 Screening Values. Lithos have discussed this matter with both NHBC and YALPAG (collection of Yorkshire & Lincolnshire local authorities) and received confirmation that they are satisfied with this approach.

With respect to **inorganic** determinands, Lithos derived Tier 1 values for the five Scenarios A to E are presented below:

Inorganic contaminant	Tier 1 assessment criteria (mg/kg) for Scenarios A to E							Comments/notes
	SGV*	C4SL*	A	B	C	D	E	
As	32	37	37	Use (A) in SI Report for initial "screen". If >5 x A, then consider increase of cover to 1,000mm	40	640	37	C4SL adopted
Cd	10	26	26		149	410	26	C4SL adopted
Cr			3,000		3,000	30,000	3,000	Assumes Cr is CrIII
Pb	450	200	200		310	2,330	200	C4SL adopted
Ni	130		127		127	1,700	127	Assessment of health risk only
Se	350		350		595	13,000	434	
Hg	170		169		238	3,640	199	Assumes in an inorganic compound
B			5		5	5	5	Based on phytotoxic risks as plants are the more sensitive receptor (Cu is pH dependant)
Cu			80-200		80-200	80-200	80-200	
Zn			200		200	200	200	

With respect to **organic** determinands, Lithos derived Tier 1 values for the five Scenarios A to E are presented below:

Organic contaminant (all sourced via CLEA)	Tier 1 assessment criteria (mg/kg) for Scenarios A to E							Comments/notes
	SGV*	C4SL*	A	B	C	D	E	
Benzene	0.33	0.87	0.9	0.9	3.3	98	N/A	C4SL adopted
Toluene	610		600	3,000	2,700	5,000	N/A	Calculated value over 10,000
Ethyl Benzene	350		350	932	843	5,000	N/A	
Xylenes	240		246	327	321	5,000	N/A	
Phenol	420		412	2,400	519	5,000	N/A	
PCBs			2	8	2	38	N/A	Based on toxicity of EC7
Benzo(a)pyrene		5	5	25	5.3	76	5	C4SL adopted. Where source is not a coal tar
Naphthalene			8	9	9	1,000	12	
Gasoline Range Organics			30	34	34	5,000	45	See 3-step assessment of TPH below
Diesel Range Organics			151	156	154	5,000	219	
Lubricating Range Org			1,000	5,000	2,000	5,000	1,000	

* *For a residential end use*

The significance of PAHs can be determined by considering indicator compounds. In most cases benzo(a)pyrene (BaP) is adopted as an indicator due to the amount of toxicological data available and has been used by various authoritative bodies to assess the carcinogenic risk of PAHs in food. A surrogate marker approach can be used to estimate the toxicity of a mixture of PAHs in soil using toxicity data for individual indicator compounds within that mixture. Exposure to the surrogate marker is assumed to represent exposure to all PAHs in that matrix. The surrogate marker approach relies on a number of assumptions:

- Surrogate marker (BaP) must be present in all soil samples
- Profile of the different PAH relative to BaP should be similar in all samples
- PAH profile in the soil samples should be similar to that used in the pivotal toxicity study[1]

[1] SP1010 Appendix E, Provisional C4SIs for benzo(a)pyrene as a surrogate marker for PAHs, CL:AIRE 2013

To assess the PAH profile in a soil sample, the ratio of the seven genotoxic PAHs (benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene and indeno[1,2,3-c,d]pyrene), relative to BaP, should be calculated. The ratio relative to BaP should lie within an order of magnitude above and below the mean ratio to BaP.

Naphthalene should also be considered separately against its generic screen. Whilst classed as a PAH, naphthalene is more volatile and mobile in the environment than most other PAHs. As such the significance of naphthalene cannot be considered within the surrogate marker approach.

Similarly, **TPH** cannot be assessed as a single "total" value, and reference has been made to the Environment Agency's document P5-080/TR3, "The UK approach for evaluating human health risks from petroleum hydrocarbons in soils". This document supports the assumptions and recommendations made by the US Total Petroleum Hydrocarbons Criteria Working Group (TPHCWG). The TPHCWG have broken down "TPH" into representative constituent fractions or "EC Bandings". The TPHCWG have derived a series of physiochemical and toxicological parameters for each of the bandings.

The significance of speciated TPH results can be assessed by following the 3 steps outlined in the tables below.

Step	Result	Action
1. Consider indicator compounds: Are BTEX, naphthalene, benzo(a)pyrene above their respective Tier 1 values?	Yes	Remediation or dQRA required
	No	Proceed to Step 2
2. Consider individual TPH fractions: are they above respective screening values?	Yes	Remediation or dQRA required
	No	Proceed to Step 3
3. Assess Cumulative effects: Is the calculated Hazard Index for each source >1	Yes	Remediation or dQRA required
	No	TPH compounds pose no significant risk

Step 1 - Assessing indicator compounds

TPH fraction Indicator compound	End use specific screening value (mg/kg)			
	A: Residential no cover	B: Residential with 600mm cover	C: Residential no gardens	D: Commercial\ industrial
Benzene	0.9	0.9	3.3	98
Toluene	600	3,000	2,700	5,000
Ethyl Benzene	350	932	843	5,000
Xylenes	246	327	321	5,000
Naphthalene	8	9	9	1,000
Benzo(a)pyrene	5	25	5.3	76

Step 2 - Assessing individual TPH fractions

TPH fraction		End use specific screening value (mg/kg)			
		A: Residential no cover	B: Residential with 600mm cover	C: Residential with no gardens	D: Commercial/ industrial
Aliphatic 5-6	GRO	41	41	42	5,000^ per fraction
Aliphatic 6-8	GRO	125	125	125	
Aliphatic 8-10	GRO	31	31	32	
Aliphatic 10-12	DRO	151	156	154	
Aliphatic 12-16	DRO	500^	500^	500^	
Aliphatic 16-21	DRO	1,000^	5,000#	1,000^	
Aliphatic 21-35	LRO	1,000^	5,000#	1,000^	
Aromatic 5-7	GRO	100	123	122	
Aromatic 7-8	GRO	30	34	34	
Aromatic 8-10	GRO	47	50	50	
Aromatic 10-12	DRO	215	287	266	
Aromatic 12-16	DRO	689	1,000*	1,000*	
Aromatic 16-21	DRO	1,000^	5,000#	1,000^	
Aromatic 21-35	LRO	1,000^	5,000#	1,000^	

* Calculated Screening Value exceeded soil saturation limit and could indicate free product, therefore calculated soil saturation limit adopted as a target

^ Calculated Screening Value close to soil saturation limit, screening value selected by Lithos considering visual and olfactory impacts.

Five times the screening value for Scenario A.

Step 3 - Assessing Cumulative Effects

$$HI = \sum_{F_i=1}^{16} HQ\ F_i = \frac{Measured\ concentration\ F_i\ (mg\,kg^{-1})}{SGV\ F_i\ (mg\,kg^{-1})}$$

where HI = Hazard Index
HQ = Hazard Quotient
F_i = Fraction $_i$
SGV = Soil Guideline Value

Other screening values used by Lithos

Tier 1 risk assessment of **hazardous gas** is undertaken through reference to the following documents (and further information is presented in Generic Note No. 5 – Hazardous Gas):

- Approved Document C, Building Regulations 2000
- Boyle & Witherington (2007) – Guidance on evaluation on development proposals on sites where methane and carbon dioxide are present, incorporating "traffic lights". Report Ref. 10627-R01-(02), for NHBC
- CIRIA C665 (2007) – Assessing risks posed by hazardous ground gases to buildings
- BS 8485:2015 – Code of Practice for the characterisation & remediation from ground gas in affected developments

With respect to the assessment of potential **phytotoxic effects** of contaminants, Lithos refer to "The Soil Code" (MAFF, 1998) for copper and zinc. The CLEA SGV is adopted for nickel due to its human health effects.

The potential risk to **building materials** is considered through reference to relevant BRE Digests, with particular emphasis on BRE Special Digest 1, 'Concrete in aggressive ground', 2005.

With respect to the interpretation of the **calorific values**, at present there are no accepted methods to assess whether a sample is combustible and under what circumstances it might smoulder. Some guidance is given in ICRCL Note 61/84 "Notes on the fire hazards of contaminated land" which states that: *"In general ... it seems likely that materials whose CV's exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn".*

Tier 1 **groundwater** risk assessments are undertaken by comparing leachate or groundwater concentrations with the appropriate water quality standard. Tier 1 Screening Values have been discussed with the Environment Agency, and typically those in **bold** below are adopted.

Analyte	Source of Tier 1 Screening Value (µg/l)			
	Surface water (Abstraction for drinking) 1996	Water Supply Regulations 2000	Water Framework Directive	EA Advice
Arsenic	50	10	**50**	
Selenium	10	**10**		
Cadmium	5	5	**1.5**	
Chromium	50	50	**32**	
Copper	50	2,000	**28**	
Lead	50	10	**7.2**	
Nickel		20	**20**	
Zinc	3,000		**125**	
Boron		**1,000**		
Mercury	1	1	**0.07**	
Petroleum Hydrocarbons				**10**
1,1,1-Trichloroethane			**100**	
1,1 Dichloroethane				**100**
1,2-Dichloroethane		3	**10**	
1,1-Dichloroethene				**100**
Benzene		1	**10**	
Ethylbenzene				**10**
Tetrachloroethene		10	**10**	
Toluene			**50**	
Trichloroethene		10	**10**	
Vinyl Chloride		**0.5**		
Trichloromethane			**2.5**	
Xylenes			**30**	
Chloroethane				**100**

Waste classification & WAC

In the context of waste soils generated by remediation and\or groundworks activities on brownfield sites, the following definitions (from the Landfill Regulations 2002) apply:

- Inert (e.g. uncontaminated 'natural' soil, bricks, concrete, tiles & ceramics)
- Non-Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances, but at concentrations below prescribed thresholds)
- Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances at concentrations above prescribed thresholds)

Dangerous substances include compounds containing a variety of determinants commonly found in contaminated soils on brownfield sites, for example arsenic, lead, chromium, benzene etc.

Landfill operators require Waste Acceptance Criteria (WAC) laboratory data, if soil waste is classified as **hazardous**, and such waste must have been subjected to pre-treatment. However, subject to WAC testing it may be possible to classify it as stable, non-reactive hazardous waste, which can be placed within a dedicated cell within the non-hazardous landfill.

Lithos typically only include WAC analysis in site investigation proposals and reports, if significant off-site disposal (of soil classified as hazardous waste) is anticipated, for example where redevelopment proposals include basement construction etc. If off-site disposal of soils classified as hazardous waste during redevelopment is anticipated, then WAC analysis should be scheduled at an early stage in the remediation programme. However, organic compounds (BTEX, TPH, PAH etc) are the most common contaminants that result in soils being classed as hazardous, and these contaminants can often be dealt with by alternative technologies (e.g. by bioremediation or stabilisation) and consequently retention on site is often possible.

It should be noted that **non-hazardous** soil waste can go to a non-hazardous landfill facility; no further testing (e.g. WAC) is required.

Possible action in event of Tier 1 exceedance

Should any of the Tier 1 criteria detailed above be exceeded, then three potential courses of action are available. (The first is only applicable in terms of human health, but the second and third could also be applied to groundwater or landfill gas).

1. Undertake further statistical analysis following the approach set out in "*Guidance on Comparing Soil Contamination Data with a Critical Concentration - CL:AIRE and CIEH, May 2008*" in order to determine whether contaminant concentrations of inorganic contaminants within soil\fill actually present a risk (only applicable to assessing the risk to human health).
2. Carry out a more detailed quantitative risk assessment in order to determine whether contamination risks actually exist.
3. Based on a qualitative risk assessment, advocate an appropriate level of remediation to "break" the pollutant linkage - for example the removal of the contaminated materials or the provision of a clean cover.

Prior to undertaking any statistical analysis the issue of the **averaging area** requires further consideration. The CL:AIRE\CIEH document still refers to CLR 7, which suggests averaging area should reflect receptor behaviour and therefore might be a single garden, or an open area used by the local community as a play area. This approach to averaging areas is considered applicable within the context of Part IIA of the Environmental Protection Act (EPA) 1990, in terms of an existing residential development.

However, Lithos consider the concept of a single garden as an averaging area to be inappropriate with respect to brownfield redevelopment, which is regulated by the planning regime. In this context, contamination across the entire site needs to be characterised by reference to the Conceptual Site Model. Consequently, Lithos gather and analyse sample results by fill type, and\or by former use in a given sub-area of the site, before undertaking statistical analysis; ie the averaging area is associated with the extent of a particular fill type, or an area affected by spillage\leakage.

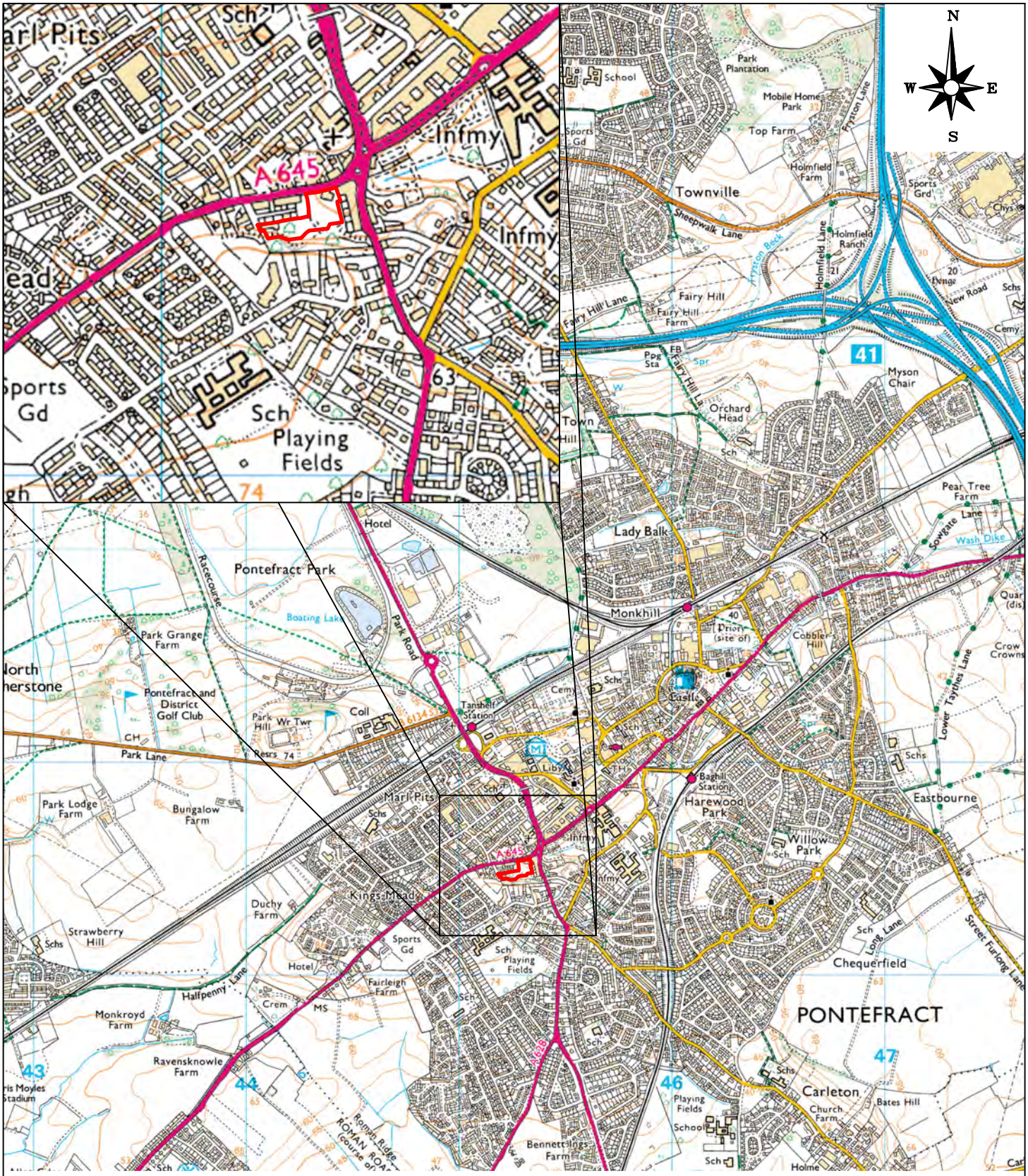
In terms of brownfield redevelopment, this is considered a more appropriate methodology which provides a more representative sample population for statistical analysis. As such the entire site is considered in terms of the proposed end use, be this residential with, or without gardens.

Analysis by soil\fill type is appropriate for essentially immobile contaminants associated with a particular fill type, for example arsenic in colliery spoil, metals in ash & clinker, sulphate in plaster-rich demolition rubble etc.

Analysis by former use is appropriate where more mobile contaminants have entered the ground, for example diesel associated with leakage from a former fuel tank, downward migration of leachable metals through granular materials, various soluble contaminants present in a wastewater leaking into the ground via a fractured sewer etc. In these circumstances, it may be appropriate to undertake statistical analysis of sample results from a variety of different soil\fill types. However, consideration would have to be given to factors such as porosity which might influence impregnation of a mobile contaminant into the soil mass, ie contamination would normally be more pervasive and significant in granular soils than cohesive soils

Appendix B

Drawings



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CLIENT	FRONTLINE ESTATES LTD
JOB TITLE	WAKEFIELD ROAD, PONTEFRACT
DRAWING TITLE	SITE LOCATION PLAN
DRAWN	WN
DATE	08 11 2021
CHECKED	AG
DATE	11 11 2021
STATUS	FOR COMMENT ☐ DRAFT ☐ FOR APPROVAL ☐ FINAL ☑
SCALE	1:25,000
SHEET	A4
DRAWING NO.	3822/1
REVISION	

Wakefield Road, PONTEFRACT

DO NOT SCALE - ALL DIMENSIONS & LEVELS TO BE CHECKED ON SITE - THIS DRAWING IS COPYRIGHT

NOTES

APPROXIMATE SITE BOUNDARY

APPROXIMATE LOCATION OF ADIT ENTRANCE

REPRODUCED FROM NIEMEN ARCHITECTS DRAWING REFERENCE 3132-1-001-D, DATED 02/05/2019

REV.	DESCRIPTION	DATE

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CLIENT

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JOB TITLE

WAKEFIELD ROAD, PONTEFRACT

DRAWING TITLE

PROPOSED SITE LAYOUT

DRAWN	DATE	STATUS
WN	08 11 2021	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
AG	11 11 2021	DRAFT ☐
		FINAL ☑

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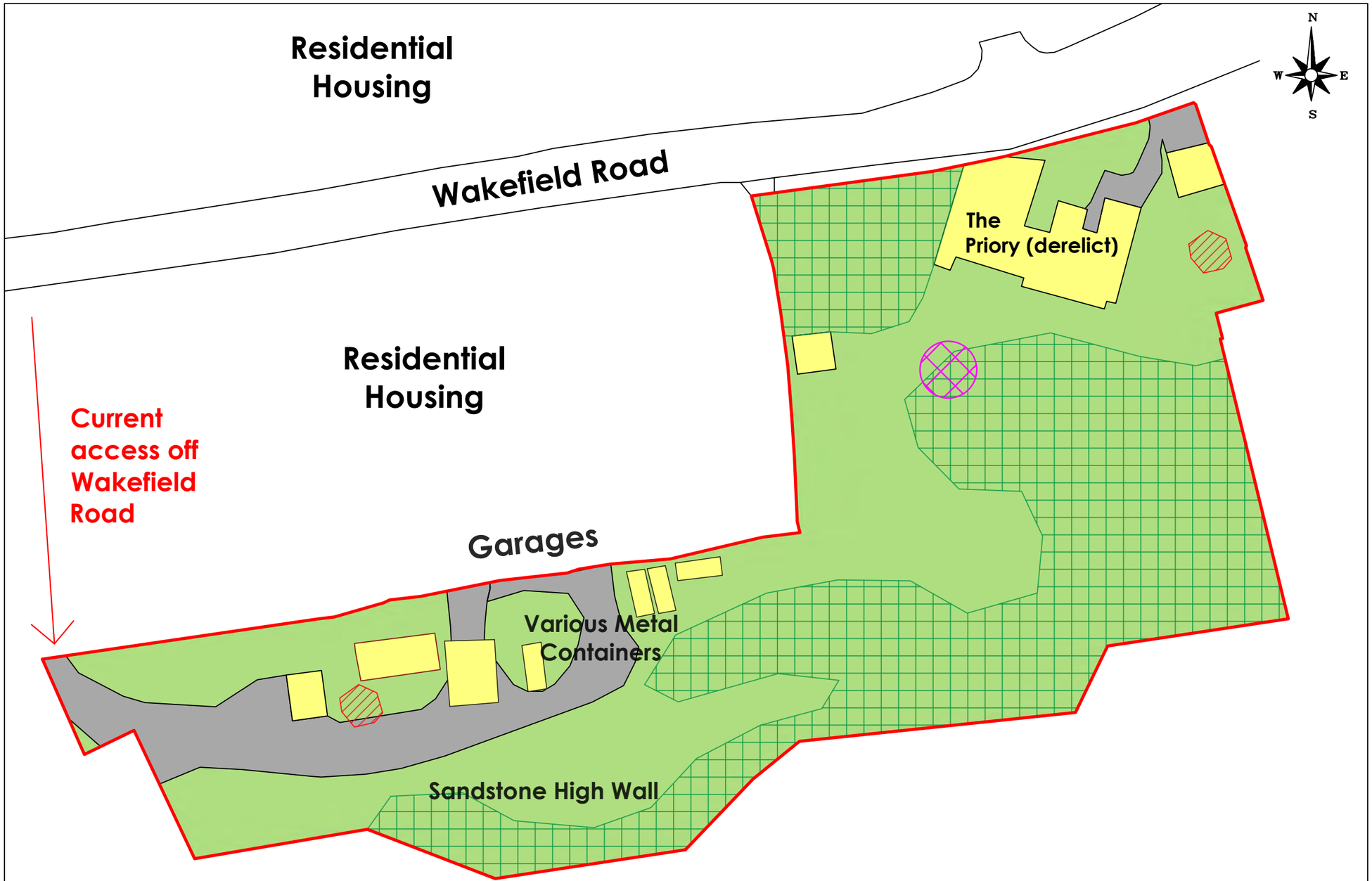

NOTES

- GRASS & OVERGROWN AREAS
- BUILDING
- TARMAC/GRAVEL HARDSTAND
- INACCESSIBLE DUE TO VEGETATION AND TOPOGRAPHY
- PRESENCE OF POSSIBLE ASBESTOS SHEETING
- APPROXIMATE LOCATION OF ADIT ENTRANCE
- APPROXIMATE SITE BOUNDARY

REV.	DESCRIPTION	DATE

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JOB TITLE

WAKEFIELD ROAD, PONTEFRACT

DRAWING TITLE

SITE FEATURES

DRAWN	DATE	STATUS
WN	08 11 2021	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
AG	11 11 2021	DRAFT ☐
		FINAL ☑

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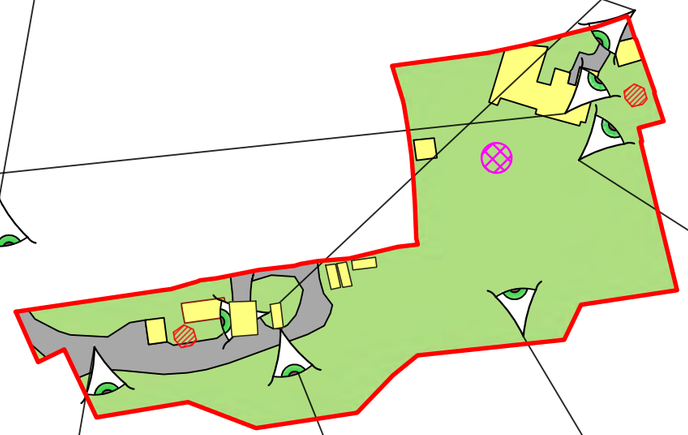

NOTES

- GRASS & OVERGROWN AREAS
- BUILDING
- TARMAC/GRAVEL HARDSTAND
- APPROXIMATE LOCATION OF ADIT ENTRANCE
- PRESENCE OF POSSIBLE ASBESTOS SHEETING
- APPROXIMATE SITE BOUNDARY
- LOCATION & ORIENTATION OF PHOTOGRAPH

REV.	DESCRIPTION	DATE

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JOB TITLE

WAKEFIELD ROAD, PONTEFRACT

DRAWING TITLE

SITE PHOTOGRAPHS

DRAWN	DATE	STATUS
WN	??	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
AG	??	DRAFT ☐
		FINAL ☑

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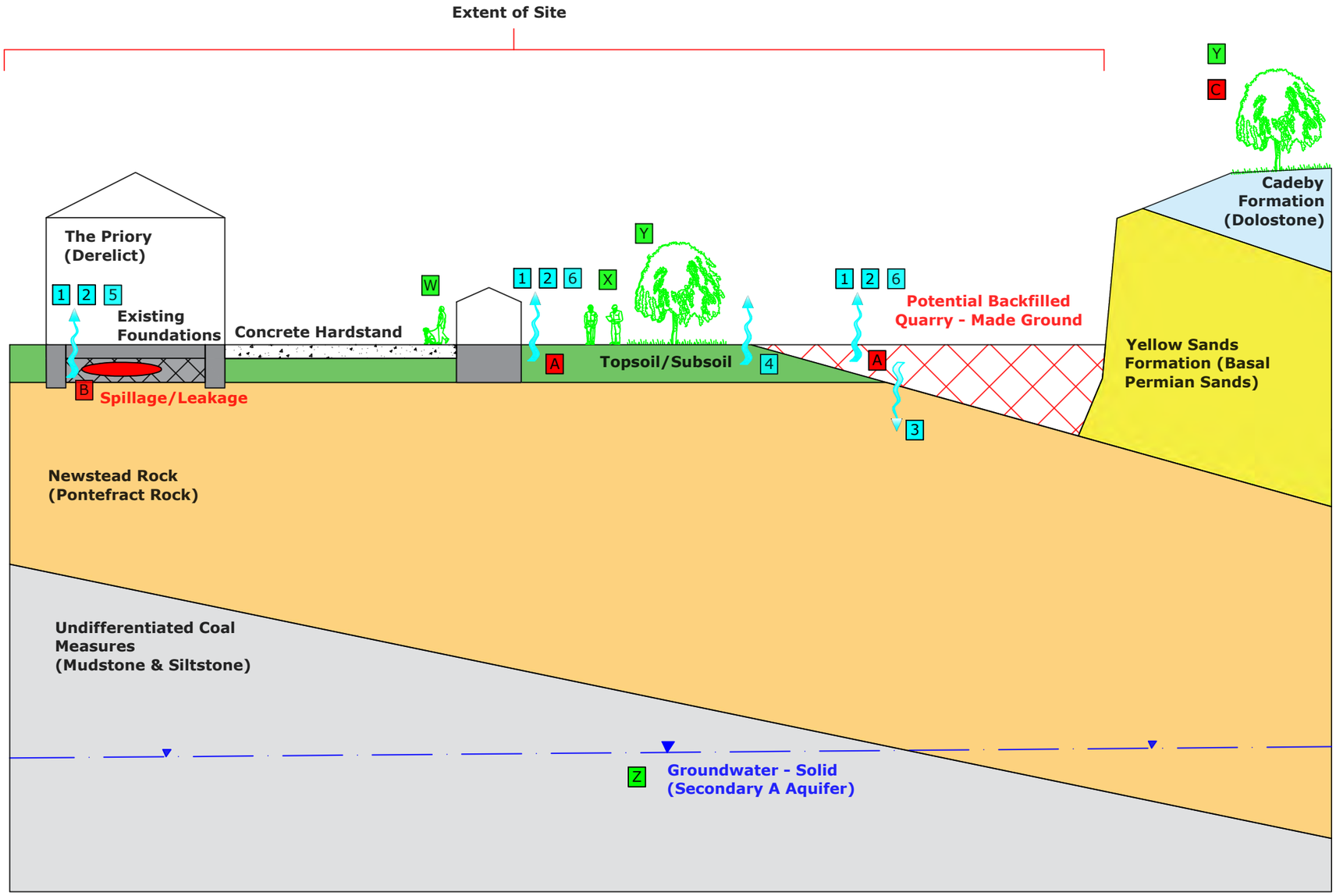

SOURCES	
A	MADE GROUND (INORGANICS)
B	LEAKAGE/SPILLAGE (ORGANICS)
C	INVASIVE PLANTS

PATHWAYS	
1	DERMAL CONTACT
2	INGESTION/INHALATION
3	LEACHING OF CONTAMINANTS
4	UPTAKE BY PLANTS
5	VOLATILISATION
6	MIGRATION OF GAS

RECEPTORS	
W	END USERS (RESIDENTS)
X	SITE WORKERS
Y	VEGETATION
Z	GROUNDWATER

NOTES

REV.	DESCRIPTION	DATE

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JOB TITLE

WAKEFIELD
ROAD,
PONTEFRACT

DRAWING TITLE

PRELIMINARY CONCEPTUAL SITE MODEL

DRAWN	DATE	STATUS
WN	8 11 2021	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
AG	9 11 2021	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
Not to scale	A3	3822/5	

NOTES

- TRIAL PIT LOCATION (NOV 2021)
- TRIAL PIT LOCATION (FEB 2022)
- BOREHOLE LOCATION (FEB 2022)
- INACCESSIBLE DUE TO VEGETATION AND TOPOGRAPHY
- PRESENCE OF POSSIBLE ASBESTOS SHEETING
- APPROXIMATE LOCATION OF ADIT ENTRANCE
- APPROXIMATE SITE BOUNDARY

EXPLORATORY HOLE LOCATIONS BASED ON DATA FROM A HAND-HELD GPS (+/- 3M ACCURACY)

REV.	DESCRIPTION	DATE

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JOB TITLE

WAKEFIELD ROAD, PONTEFRACT

DRAWING TITLE

EXPLORATORY HOLE LOCATIONS

DRAWN	DATE	STATUS
WN	14 02 2022	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
AG	17 02 2022	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
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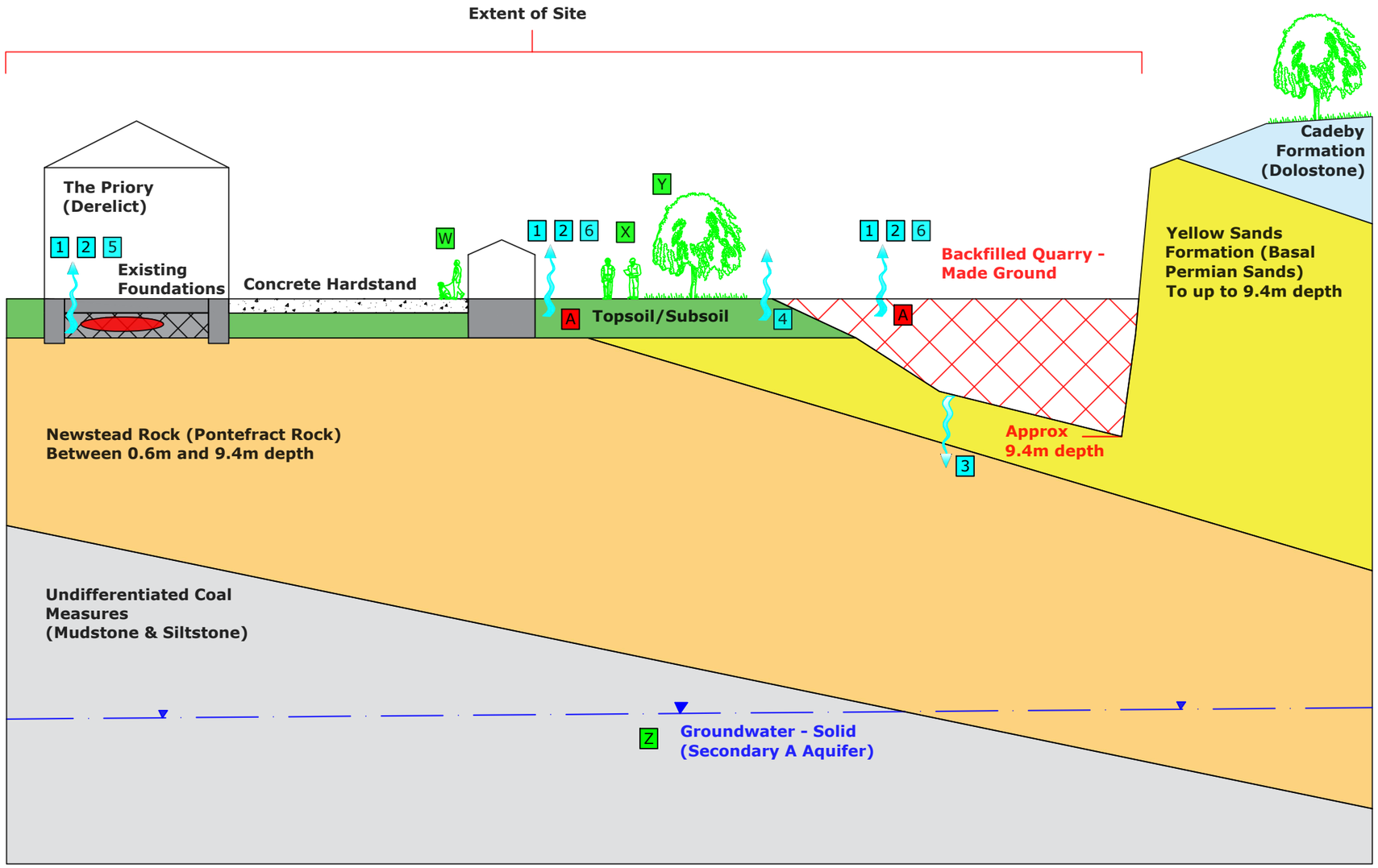

SOURCES	PATHWAYS	RECEPTORS
A MADE GROUND (INORGANICS/ORGANICS)	1 DERMAL CONTACT	W END USERS (RESIDENTS)
	2 INGESTION/INHALATION	X SITE WORKERS
	3 LEACHING OF CONTAMINANTS	Y VEGETATION
	4 UPTAKE BY PLANTS	Z GROUNDWATER
	5 VOLATILISATION	
	6 MIGRATION OF GAS	

NOTES

REV.	DESCRIPTION	DATE

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JOB TITLE

WAKEFIELD
ROAD,
PONTEFRACT

DRAWING TITLE

REVISED CONCEPTUAL SITE MODEL

DRAWN	DATE	STATUS
WN	14 02 2022	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
AG	17 02 2022	DRAFT ☐
		FINAL ☑

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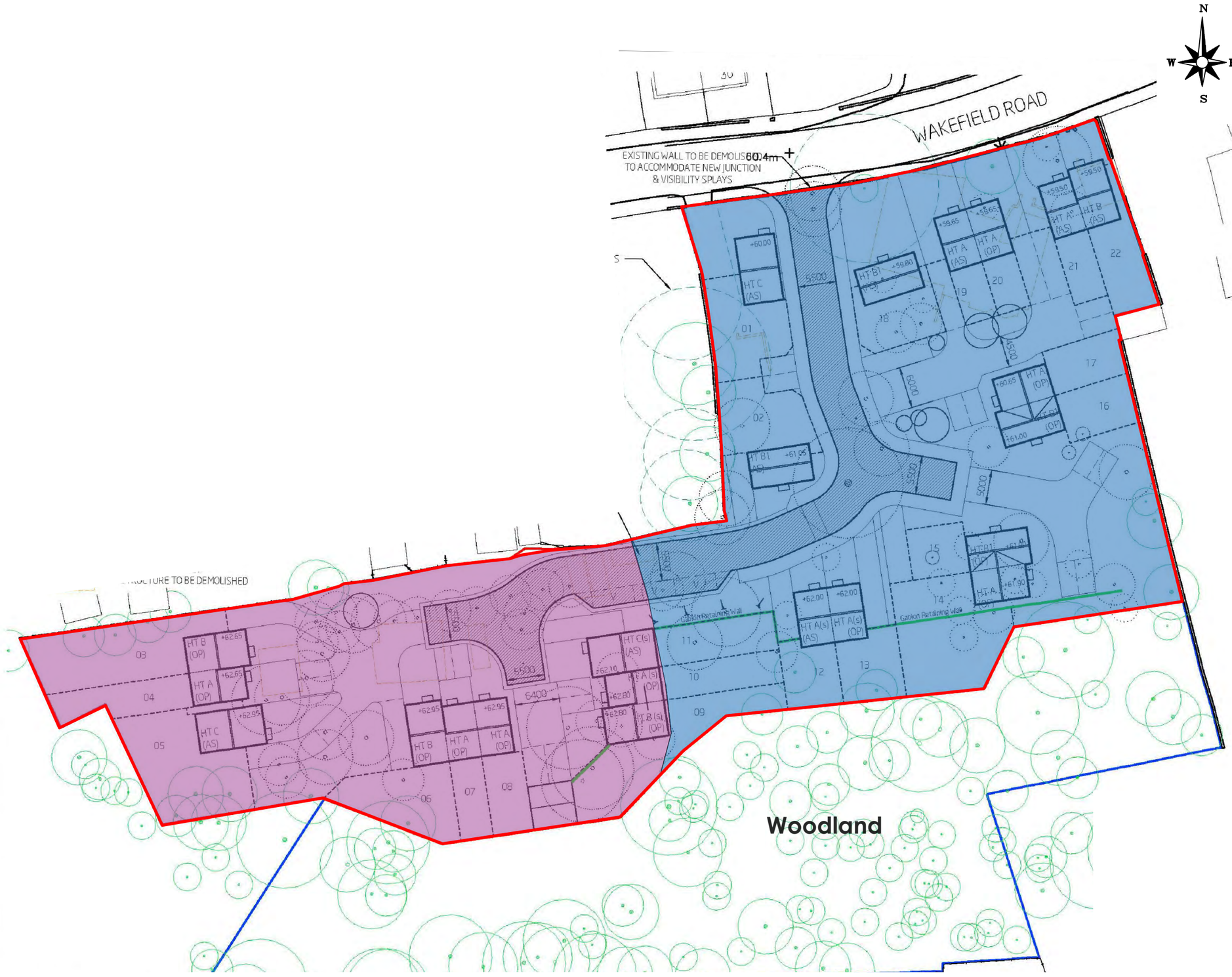

NOTES

AREA A

AREA B

APPROXIMATE SITE BOUNDARY

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JOB TITLE

WAKEFIELD ROAD, PONTEFRACT

DRAWING TITLE

SITE AREAS

DRAWN	DATE	STATUS
WN	14 02 2022	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
AG	17 02 2022	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:600	A3	3822/8	

Appendix C

Commission

002/3822/REG

8th June 2020

Mr R Weatherhead
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Dear Richard

Wakefield Road Pontefract

Further to your recent invitation, please find attached our proposal for undertaking a site investigation on the above land. We understand that your proposed development will include traditional 2 storey domestic dwellings with associated gardens, POS and adoptable roads and sewers; a sketch layout showing 22 units has been provided.

Review of the information supplied suggests that the site consists of a single parcel of land of approximately 1.4 hectares, although development is restricted to 0.8ha in the north. Review of Google Maps suggests the land is overgrown with some derelict and partially demolished buildings.

Brief review of Old Maps and Environment Agency data suggests:

- Land in the north has been occupied by a building called The Priory with surrounding gardens and ponds, with Priory Woods in the south.
- There are several former quarries in the vicinity.
- Is not located within 250m of a known landfill site.
- Is not within a groundwater source protection zone.

Brief examination of the relevant geological map suggests the site is directly underlain by Sandstone, possibly with Basal Permian Sand (BPS) and Cadeby Formation Limestone in the far south-west. The BPS is generally 2m to 3m thick and comprises virtually pure quartz sand. It has been mined in the Castleford-Pontefract area since the late 1700s for glassmaking and moulding sand used in iron foundries.

This site is located within a Coal Mining Development Low Risk Area an intrusive mining investigation should not be required).

The scope of works outlined in this letter should enable us to assess abnormal development issues, associated with ground. However, the nature of site investigation is such that it is not always possible to foresee all the potential issues. Consequently, it is sometimes necessary to recommend additional work, but where this occurs we will inform you immediately, provide costs, and seek your further instruction. We have visited site and reviewed available internet data and our geological maps in order to minimise the likelihood of further work.

We will need a Promap or topo survey in CAD format, to provide a base plan for technical drawings etc. If you do not have one, we could obtain at cost plus £***.

Our site investigation will be undertaken in accordance with UK good practice (as outlined in BS5930, BS10175, CLR11 etc). Our Report may not be fully compliant with Eurocode 7 (EC7) and will not purport to be a Ground Investigation Report, nor a Geotechnical Design Report as defined by EC7.

Our ground appraisal is intended to assist others as they proceed with design of the proposed development.

This proposal allows for the following works:

Desk study: Environmental search data and historical maps (obtained from Landmark or Groundsure), will be reviewed in order to determine whether past land uses have had any effect on the proposed development. In addition, published geological plans of the area will be examined.

Given the site's location within a Coal Mining Low Risk Area, a Consultant's mining report will be obtained.

We will also visit site to undertake a walkover survey.

Fieldwork: We have allowed for a day's trial pitting with all pits to be supervised and logged by an experienced geoenvironmental engineer.

This proposal has been put together without a recent site visit. If ground conditions are found to be significantly wet/boggy at the time of the investigation, it may be necessary to hire additional resources (bog mats, tracked excavators, tractors, stone etc) in order for works to continue. We will discuss the requirement for any such items and associated costs with you prior to ordering.

Trial pitting will enable us to determine the:

- Nature of any made ground, including:
  - visual/olfactory evidence of potential contamination and the proportion of undesirable elements e.g. biodegradable matter, relict foundations etc
  - the proportion of "oversize", boulder-sized material
- Nature, distribution and thickness of shallow soils
- Suitability of the ground for founding structures and highways

Representative soil samples of natural and man-made ground, including any contaminated samples, will be taken during the works. In-situ shear strengths of any cohesive soils encountered will be determined by the use of a hand-held shear vane.

We will make every effort to compact arisings and 'sweep' them over each trial pit. However, you should be aware that on completion of the investigation, "graves" of spoil (each about 3m long by 1m wide) unsuitable for trafficking, will be left up to 400mm proud at each trial pit location. At this stage, no allowance has been made for any further reinstatement such as removal of excess arisings, replacement of turf.

If the pitting encounters significant thicknesses of made ground or very soft/loose deposits (neither considered likely), boreholes may be required to obtain geotechnical data from greater depth. We will advise you of any need for boreholes within 2 days of completion of the pitting.

Based on anticipated ground, **soakaways** are might provide a satisfactory solution for surface water drainage, but no allowance has been made for soakaway testing at this stage.

Representative soil samples of natural and man-made ground, including any contaminated samples, will be taken during the works. In-situ shear strengths of any cohesive soils encountered will be determined by the use of a hand-held shear vane.

Exploratory holes will be positioned a hand-held GPS (typically +/- 3m accuracy); if required we could arrange for a **surveyor** to pick-up exploratory holes (and provide co-ordinates/ground levels) for an E\O cost of £***.

This site is greenfield and therefore highly unlikely to be underlain by significant thicknesses of made ground. Furthermore, we are not aware of any other sources of hazardous **gas** (shallow mine workings, landfill sites etc) within influencing distance of the site.

Consequently, at this stage, we have not allowed for undertaking a hazardous gas risk assessment but we will review the need for this in light of desk study data and the ground conditions actually encountered.

Testing: This will comprise routine **geotechnical** soils analysis, including 10 moisture content & Atterberg limits, and 10 pH & water-soluble sulphate.

At this stage, we have no reason to expect wide areas of the site to be underlain by significant thicknesses of made ground. Consequently, we have only allowed for **contaminant** testing of up to 9 made ground samples, plus a further 6 samples of topsoil to confirm its suitability for re-use. The test suite will include heavy metals, speciated PAH, and banded TPH (with supplementary speciation as/where appropriate).

Within in our proposal we have allowed for the screening (ID) of 15 samples for asbestos. In the event that positive IDs are reported, it is likely that we will need to schedule further analysis (asbestos quantification), in order to determine the significance of the results. Asbestos quantification is currently a relatively expensive test and consequently we have not allowed for it at this stage. We will inform you immediately after receipt of results if we consider asbestos quantification is required.

Reporting & timescales: In order to provide you with sufficient information to enable assessment of abnormal costs at the earliest opportunity we will issue a concise overview report within 3 days of fieldwork completion.

On completion of the desk study, fieldwork and laboratory testing a comprehensive, factual and interpretative report will be issued. This will contain detailed engineering records, laboratory test results, copies of all relevant correspondence and drawings of the site. The report will include qualitative risk assessment with respect to both controlled waters and human health. The report will also include consideration of foundation types.

At the time of writing, fieldwork could be commenced within 3 weeks of receipt of your written instruction to proceed. Our comprehensive geoenvironmental appraisal report will be issued within 4 weeks of fieldwork completion.

A completed copy of the **YW** Contaminated Land Assessment Form will be included in an Appendix to our Report.

A copy of the final report will be issued to the relevant regulatory authorities on receipt of written instruction from yourselves.

Invoicing: The attached proposal provides a breakdown of the costs associated with this project. This breakdown is for information only and the proposal can be regarded as a lump sum price of **£*** plus VAT. Variation will only occur in the event that a given item is not undertaken or that substantial additional works are recommended, in which case we will inform you immediately, provide costs for the required works, and seek your prior consent.

Our proposal allows for submission of the report to the Local Authority and NHBC, and for submission of a single piece of subsequent correspondence with each regulator to address any queries they may have. Any further meetings, correspondence etc, would be chargeable.

We will submit invoices for this project at the milestones defined below:

- 1st milestone invoice (Item A) on issue of the Desk Study report
- 2nd and final invoice (Items B to D) on issue of the final SI report

Health, safety & welfare: The works outlined above will be carried out in accordance with Lithos' task- and site- specific Risk Assessments and Method Statements.

Details of welfare will be included within the Method Statements. However, this investigation is expected to be completed within a working day and therefore it is not considered reasonably practicable to provide formal welfare facilities, and our proposal makes no allowance for so doing.

Utility plans are required in order to protect operatives from the hazards associated with striking buried services and avoid potentially substantial disruption\repair costs. We will make every effort not to damage any services (including review of utility plans and use of a CAT detector). However, Lithos cannot accept liability for damage to any underground services that are not accurately marked on plans made available to us prior to commencement of our field investigation, or have not been accurately marked on the ground by a responsible third party (e.g. utility company, site owner).

Most developers have copies of the necessary utility plans (including electricity, gas, water, drainage & telecom), and it would be appreciated if you could forward these prior to the proposed fieldworks. However, if you do not have the necessary plans, Lithos will obtain them direct from each of the utility companies.

Under the **CDM** Regulations 2015, Lithos must be provided with pre-construction information already in your possession, or information that can reasonably be obtained through sensible enquiry. This information must be relevant to the project, have an appropriate level of detail, and be proportionate to the nature of the risks.

If no other designers or contractors have been appointed, Lithos could perform the role of Principal Designer and/or Principal Contractor but only for the duration of the site investigation outlined in this proposal. If you require us to perform the role of Principal Designer and/or Principal Contractor, please make this clear in your instruction. It should be noted that we are not suitably qualified to perform either role where other designers or contractors are also appointed.

It is anticipated that the site investigation outlined in this proposal will be undertaken several months before any construction is commenced on site. Consequently, our works can be considered in isolation and, given the anticipated number of person days on site, this site investigation is not notifiable to the HSE.

Terms & conditions: This work will be undertaken in accordance with our Standard Terms and Conditions, a copy of which are enclosed.

At the time of writing, we understand that our report is solely for Frontline's benefit. However, it is anticipated that eventually a third party (the Developer) will wish to rely on our report. We confirm that we will assign, free of charge, the benefit of our Report(s) to the Developer on receipt of an instruction from Frontline.

It is hoped the above is sufficient for your present needs. However, should you require any further information, please contact the undersigned.

Yours sincerely

Mark Perrin
Director
for and on behalf of
LITHOS CONSULTING LIMITED

Will Newton

Subject: FW: 3822 - Wakefield Road, Pontefract - Prelim Summary

---

From: Richard Weatherhead <richard@frontlineestates.co.uk>
Sent: 26 November 2021 16:52
To: Adam Gombocz <Adam.Gombocz@lithos.co.uk>
Subject: Re: 3822 - Wakefield Road, Pontefract - Prelim Summary

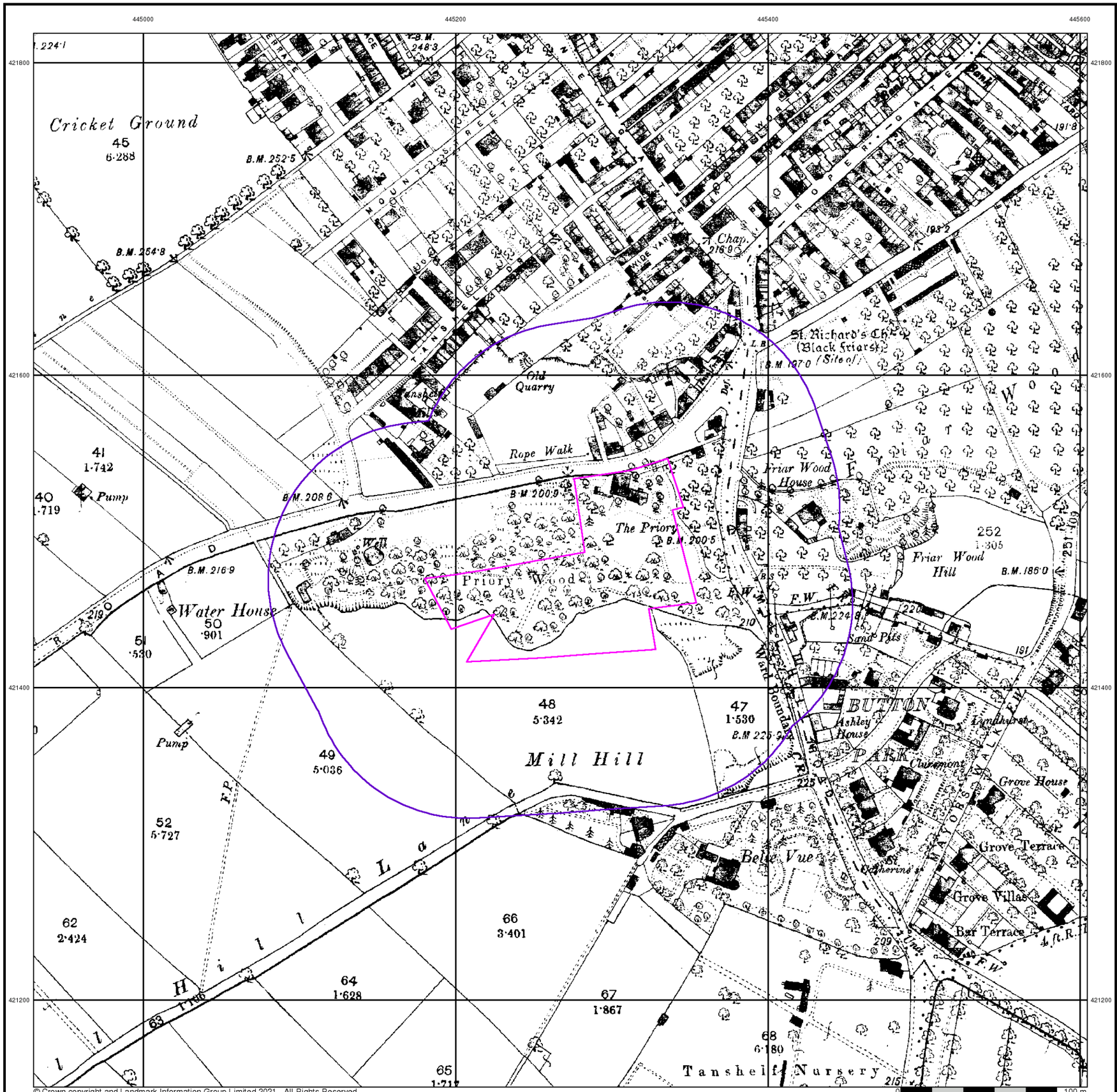
Many thanks, Adam and yes please book us in for that ASAP post Christmas. Can we / do we need to determine the extent of the MG or are we just doing the 3 blocks that we know are on it ?

Regards
Richard
Richard Weatherhead FRICS
Director
07880 588950

> On 26 Nov 2021, at 17:41, Adam Gombocz <Adam.Gombocz@lithos.co.uk> wrote:
>
> Afternoon Richard,
>
> Updated invoice attached as requested.
>
> With regards to the additional SI, I have attached my previous email sent last week, but in summary the drilling of 3 No. cable percussive boreholes to the base of the made ground (with SPTs), plus gas monitoring installations (but without monitoring) and reporting the cost is c. £***k.
>
> Drilling rig availability now means that the boreholes would have to take place after Christmas.
>
> Let me know if you want to proceed and I will formalise the above into a quote.
>
> Have a nice weekend,
>
> Kind regards,
>
> **Adam Gombocz** <image001.jpg> <image002.png>
> **Associate Director**
> **Lithos Consulting Ltd**
> **M 07951 497021**
> **DD 01937 543 353**
> **www.lithos.co.uk**

Appendix D

Historical OS Plans



LITHOS CONSULTING

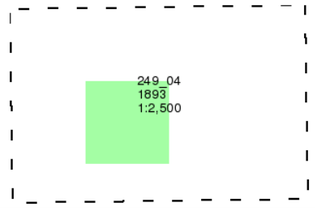
Yorkshire

Published 1893

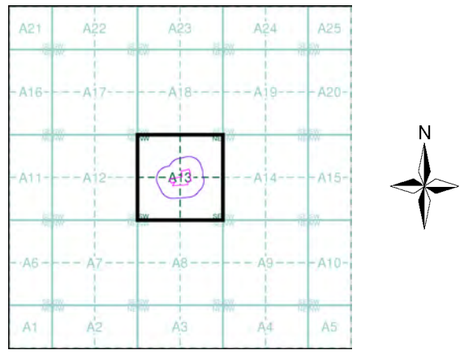
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



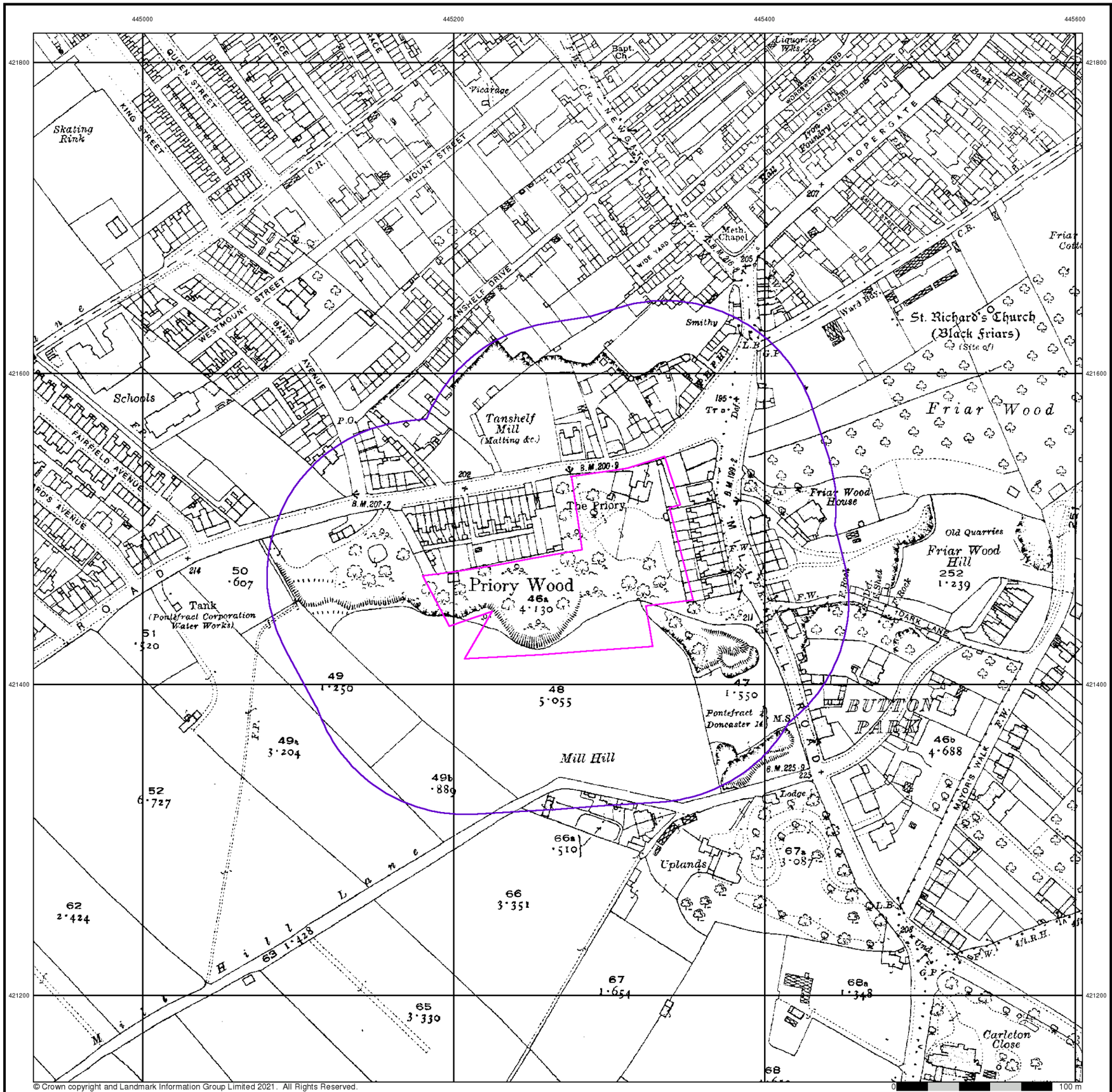
Order Details

Order Number:	286961054_1_1
Customer Ref:	PO18243/JW/3822
National Grid Reference:	445270, 421480
Slice:	A
Site Area (Ha):	1.2
Search Buffer (m):	100

Site Details

Wakefield Road, Pontefract, West Yorkshire, WF8 4HW

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



LITHOS CONSULTING

Yorkshire

Published 1922

Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

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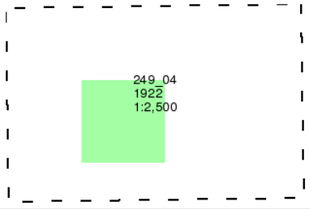
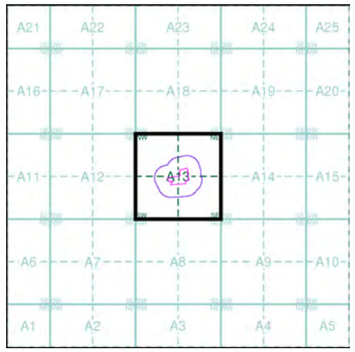


Historical Map - Segment A13



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Fax: 0844 844 9951
Web: www.envirocheck.co.uk

LITHOS CONSULTING

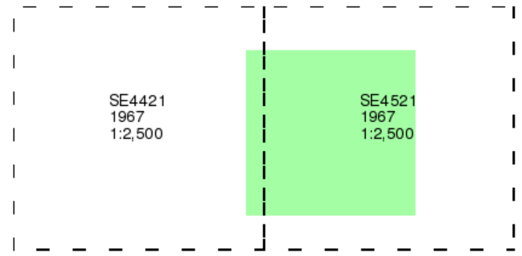
Ordnance Survey Plan

Published 1967

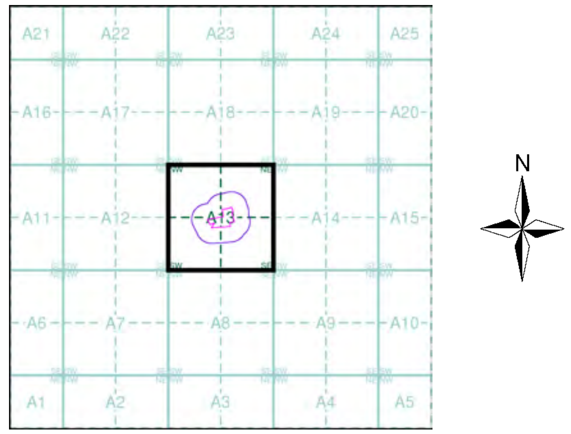
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



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Slice: A
Site Area (Ha): 1.2
Search Buffer (m): 100

Site Details

Wakefield Road, Pontefract, West Yorkshire, WF8 4HW

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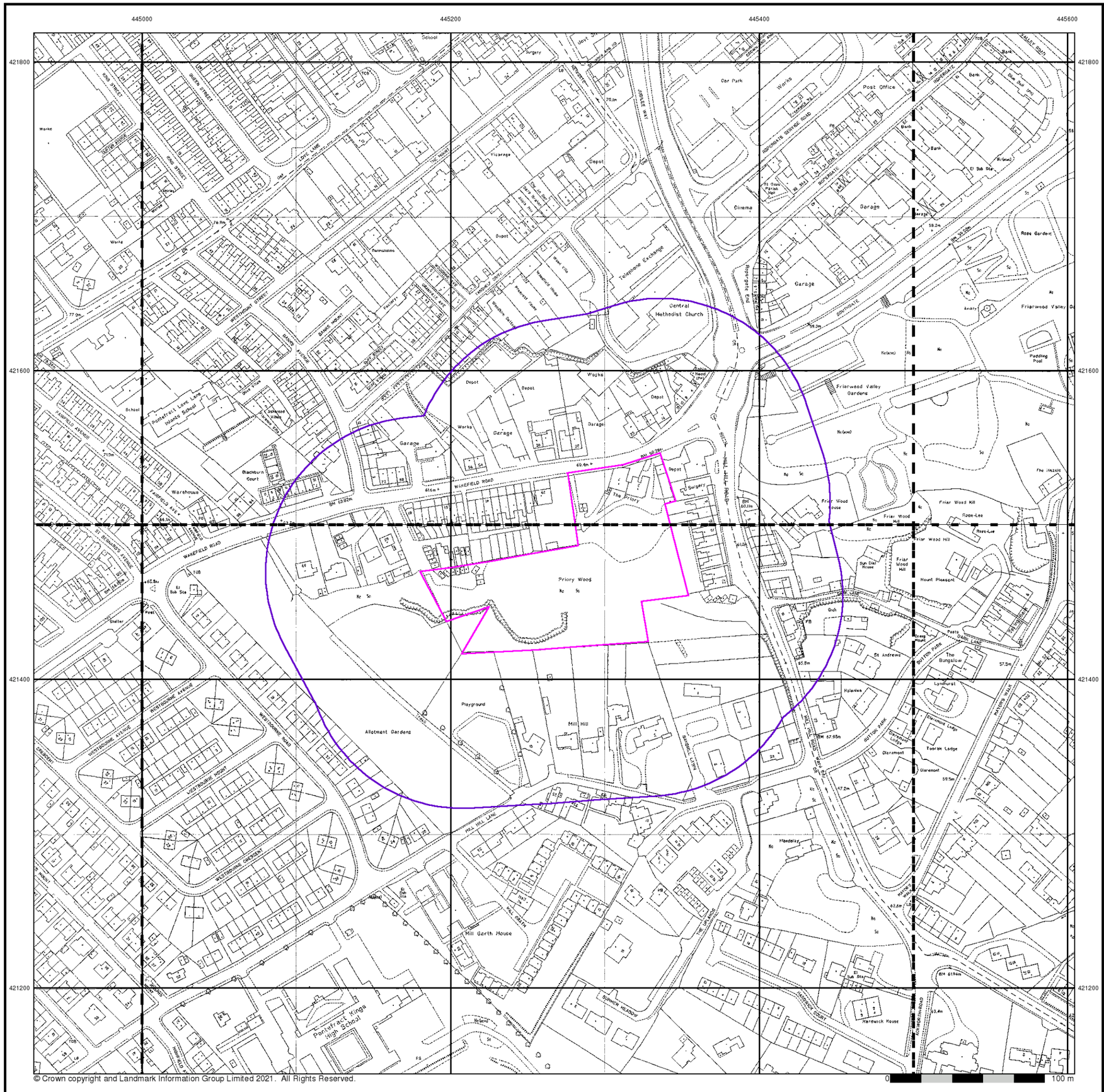


LITHOS CONSULTING

Large-Scale National Grid Data

Published 1993

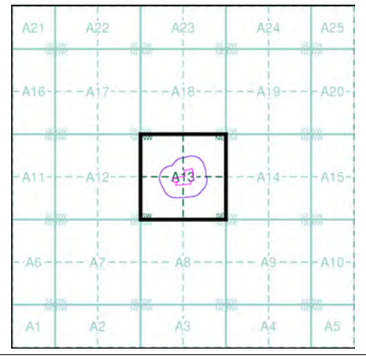
Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)

SE4421NE 1993 1:1,250	SE4521NW 1993 1:1,250	SE4521NE 1993 1:1,250
SE4421SE 1993 1:1,250	SE4521SW 1993 1:1,250	SE4521SE 1993 1:1,250

Historical Map - Segment A13



Order Details

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National Grid Reference:	445270, 421480
Slice:	A
Site Area (Ha):	1.2
Search Buffer (m):	100

Site Details

Wakefield Road, Pontefract, West Yorkshire, WF8 4HW

Landmark INFORMATION GROUP

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Web: www.envirocheck.co.uk

Appendix E

Search Responses & other Correspondence

Envirocheck® Report:

Datasheet

Order Details:

Order Number:
286961054_1_1

Customer Reference:
PO18243/JW/3822

National Grid Reference:
445270, 421480

Slice:
A

Site Area (Ha):
1.2

Search Buffer (m):
1000

Site Details:

Wakefield Road
Pontefract
West Yorkshire
WF8 4HW

Client Details:

Mr M Perrin
Lithos Consulting Ltd
Parkhill
Walton Road
Wetherby
LS22 5DZ

Contents

Introduction

The Environment Act 1995 has made site sensitivity a key issue, as the legislation pays as much attention to the pathways by which contamination could spread, and to the vulnerable targets of contamination, as it does the potential sources of contamination.
For this reason, Landmark's Site Sensitivity maps and Datasheet(s) place great emphasis on statutory data provided by the Environment Agency/Natural Resources Wales and the Scottish Environment Protection Agency; it also incorporates data from Natural England (and the Scottish and Welsh equivalents) and Local Authorities; and highlights hydrogeological features required by environmental and geotechnical consultants. It does not include any information concerning past uses of land. The datasheet is produced by querying the Landmark database to a distance defined by the client from a site boundary provided by the client.
In this datasheet the National Grid References (NGRs) are rounded to the nearest 10m in accordance with Landmark's agreements with a number of Data Suppliers.

Report Version v53.0

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Summary

Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m (*up to 2000m)
Agency & Hydrological					
BGS Groundwater Flooding Susceptibility	pg 1	Yes	Yes	Yes	n/a
Contaminated Land Register Entries and Notices					
Discharge Consents	pg 1			1	3
Prosecutions Relating to Controlled Waters			n/a	n/a	n/a
Enforcement and Prohibition Notices					
Integrated Pollution Controls					
Integrated Pollution Prevention And Control	pg 2			6	
Local Authority Integrated Pollution Prevention And Control					
Local Authority Pollution Prevention and Controls	pg 3		3	2	8
Local Authority Pollution Prevention and Control Enforcements					
Nearest Surface Water Feature	pg 5		Yes		
Pollution Incidents to Controlled Waters	pg 5			2	6
Prosecutions Relating to Authorised Processes					
Registered Radioactive Substances	pg 7			7	1
River Quality					
River Quality Biology Sampling Points					
River Quality Chemistry Sampling Points					
Substantiated Pollution Incident Register	pg 8	3			1
Water Abstractions	pg 8				(*4)
Water Industry Act Referrals					
Groundwater Vulnerability Map	pg 9	Yes	n/a	n/a	n/a
Groundwater Vulnerability - Soluble Rock Risk	pg 10	1	n/a	n/a	n/a
Groundwater Vulnerability - Local Information			n/a	n/a	n/a
Bedrock Aquifer Designations	pg 10	Yes	n/a	n/a	n/a
Superficial Aquifer Designations			n/a	n/a	n/a
Source Protection Zones					
Extreme Flooding from Rivers or Sea without Defences				n/a	n/a
Flooding from Rivers or Sea without Defences				n/a	n/a
Areas Benefiting from Flood Defences				n/a	n/a
Flood Water Storage Areas				n/a	n/a
Flood Defences				n/a	n/a
OS Water Network Lines	pg 10		1	3	10

Summary

Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m (*up to 2000m)
Waste					
BGS Recorded Landfill Sites					
Historical Landfill Sites					
Integrated Pollution Control Registered Waste Sites					
Licensed Waste Management Facilities (Landfill Boundaries)					
Licensed Waste Management Facilities (Locations)	pg 13			1	1
Local Authority Landfill Coverage	pg 13	1	n/a	n/a	n/a
Local Authority Recorded Landfill Sites					
Potentially Infilled Land (Non-Water)	pg 13		2		1
Potentially Infilled Land (Water)	pg 13				9
Registered Landfill Sites					
Registered Waste Transfer Sites	pg 14			1	1
Registered Waste Treatment or Disposal Sites					
Hazardous Substances					
Control of Major Accident Hazards Sites (COMAH)					
Explosive Sites					
Notification of Installations Handling Hazardous Substances (NIHHS)					
Planning Hazardous Substance Consents					
Planning Hazardous Substance Enforcements					

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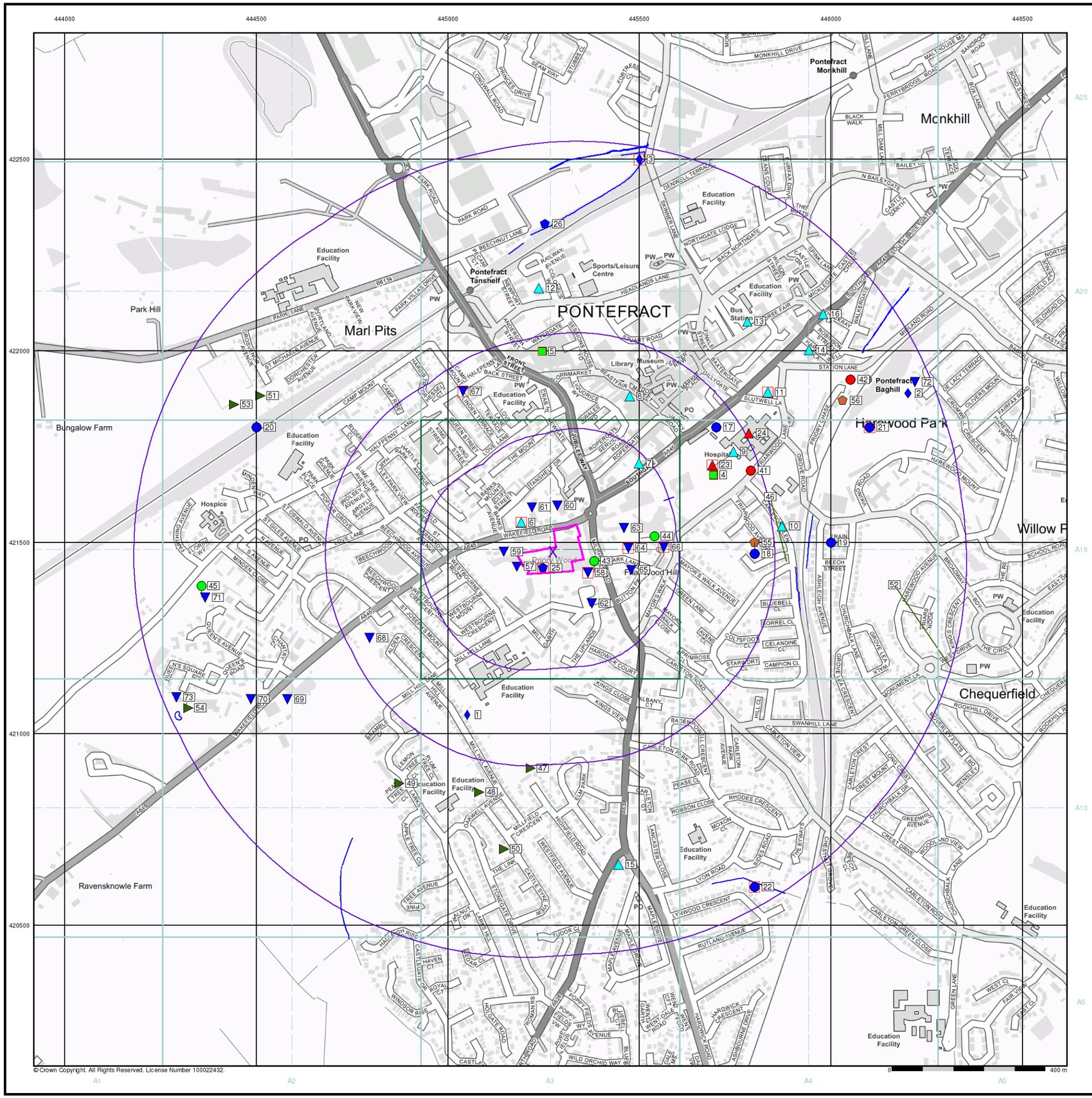
Summary

Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m (*up to 2000m)
Geological					
BGS 1:625,000 Solid Geology	pg 15	Yes	n/a	n/a	n/a
BGS Estimated Soil Chemistry	pg 15	Yes	Yes	Yes	Yes
BGS Recorded Mineral Sites	pg 20	1	14	3	5
BGS Urban Soil Chemistry					
BGS Urban Soil Chemistry Averages					
CBSCB Compensation District			n/a	n/a	n/a
Coal Mining Affected Areas	pg 23	Yes	n/a	n/a	n/a
Mining Instability	pg 24	Yes	n/a	n/a	n/a
Man-Made Mining Cavities	pg 24		1		
Natural Cavities					
Non Coal Mining Areas of Great Britain	pg 24	Yes	Yes	n/a	n/a
Potential for Collapsible Ground Stability Hazards	pg 24	Yes	Yes	n/a	n/a
Potential for Compressible Ground Stability Hazards				n/a	n/a
Potential for Ground Dissolution Stability Hazards	pg 24	Yes	Yes	n/a	n/a
Potential for Landslide Ground Stability Hazards	pg 25	Yes	Yes	n/a	n/a
Potential for Running Sand Ground Stability Hazards	pg 25	Yes	Yes	n/a	n/a
Potential for Shrinking or Swelling Clay Ground Stability Hazards	pg 25		Yes	n/a	n/a
Radon Potential - Radon Affected Areas			n/a	n/a	n/a
Radon Potential - Radon Protection Measures			n/a	n/a	n/a
Industrial Land Use					
Contemporary Trade Directory Entries	pg 26		26	32	79
Fuel Station Entries	pg 38		2		2
Points of Interest - Commercial Services	pg 38		8	1	36
Points of Interest - Education and Health	pg 42			3	2
Points of Interest - Manufacturing and Production	pg 42		6	10	17
Points of Interest - Public Infrastructure	pg 45		1	4	23
Points of Interest - Recreational and Environmental	pg 47		1	1	3
Gas Pipelines					
Underground Electrical Cables					

Summary

Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m (*up to 2000m)
Sensitive Land Use					
Ancient Woodland					
Areas of Adopted Green Belt	pg 49			1	
Areas of Unadopted Green Belt					
Areas of Outstanding Natural Beauty					
Environmentally Sensitive Areas					
Forest Parks					
Local Nature Reserves					
Marine Nature Reserves					
National Nature Reserves					
National Parks					
Nitrate Sensitive Areas					
Nitrate Vulnerable Zones	pg 49	1		1	1
Ramsar Sites					
Sites of Special Scientific Interest					
Special Areas of Conservation					
Special Protection Areas					
World Heritage Sites					



LITHOS CONSULTING

General

Specified Site
Specified Buffer(s)
Bearing Reference Point
Map ID
Several of Type at Location

Agency and Hydrological

Contaminated Land Register Entry or Notice (Location)
Contaminated Land Register Entry or Notice
Discharge Consent
Enforcement or Prohibition Notice
Integrated Pollution Control
Integrated Pollution Prevention Control
Local Authority Integrated Pollution Prevention and Control
Local Authority Pollution Prevention and Control
Local Authority Pollution Prevention and Control Enforcement
Pollution Incident to Controlled Waters
Prosecution Relating to Authorised Processes
Prosecution Relating to Controlled Waters
Registered Radioactive Substance
River Network or Water Feature
River Quality Sampling Point
Substantiated Pollution Incident Register
Water Abstraction
Water Industry Act Referral

Hazardous Substances

COMAH Site
Explosive Site
NIHHS Site
Planning Hazardous Substance Consent
Planning Hazardous Substance Enforcement

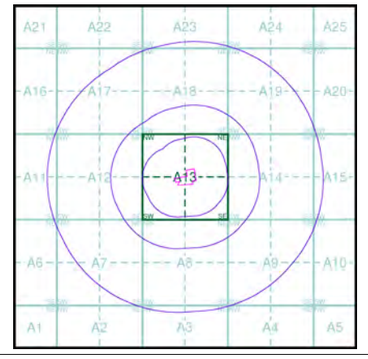
Geological

BGS Recorded Mineral Site

Waste

BGS Recorded Landfill Site (Location)
BGS Recorded Landfill Site
EA Historic Landfill (Buffered Point)
EA Historic Landfill (Polygon)
Integrated Pollution Control Registered Waste Site
Licensed Waste Management Facility (Landfill Boundary)
Licensed Waste Management Facility (Location)
Local Authority Recorded Landfill Site (Location)
Local Authority Recorded Landfill Site
Potentially Infilled Land (Non-water)
Potentially Infilled Land (Non-water)
Potentially Infilled Land (Non-water)
Potentially Infilled Land (Water)
Potentially Infilled Land (Water)
Potentially Infilled Land (Water)
Registered Landfill Site
Registered Landfill Site (Location)
Registered Landfill Site (Point Buffered to 100m)
Registered Landfill Site (Point Buffered to 250m)
Registered Waste Transfer Site (Location)
Registered Waste Transfer Site
Registered Waste Treatment or Disposal Site (Location)
Registered Waste Treatment or Disposal Site

Site Sensitivity Map - Slice A



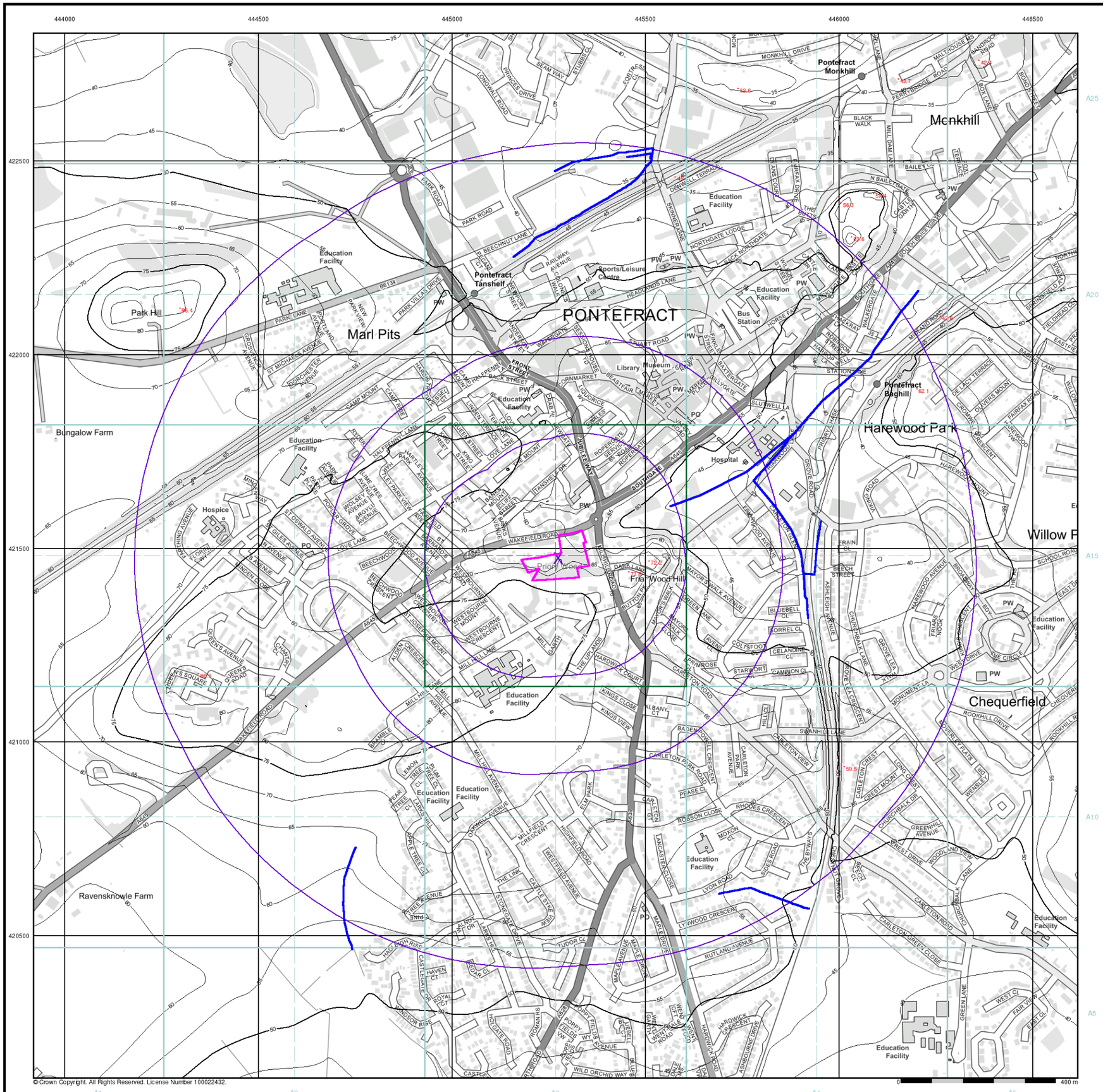
Order Details

Order Number:	286961054_1_1
Customer Ref:	PO18243/JW/3822
National Grid Reference:	445270, 421480
Slice:	A
Site Area (Ha):	1.2
Search Buffer (m):	1000

Site Details

Wakefield Road, Pontefract, West Yorkshire, WF8 4HW

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



LITHOS CONSULTING

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point

OS Water Network Data

- Canal
- Reservoir
- Foreshore
- Marsh
- Tidal River
- Inland River
- Drain
- Other
- Lake
- Transfer
- Lock Or Flight Of Locks
- Sea

Contours (height in meters)

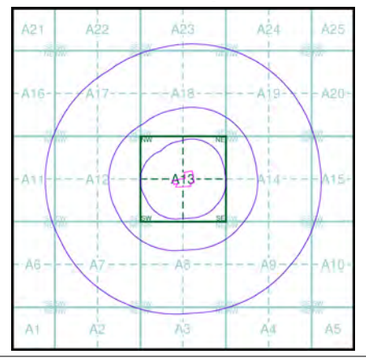
Standard Contour 105 100 95

Master Contour

Spot Height 167.3

- MLW Mean Low Water
- MHW Mean High Water

OS Water Network Map - Slice A



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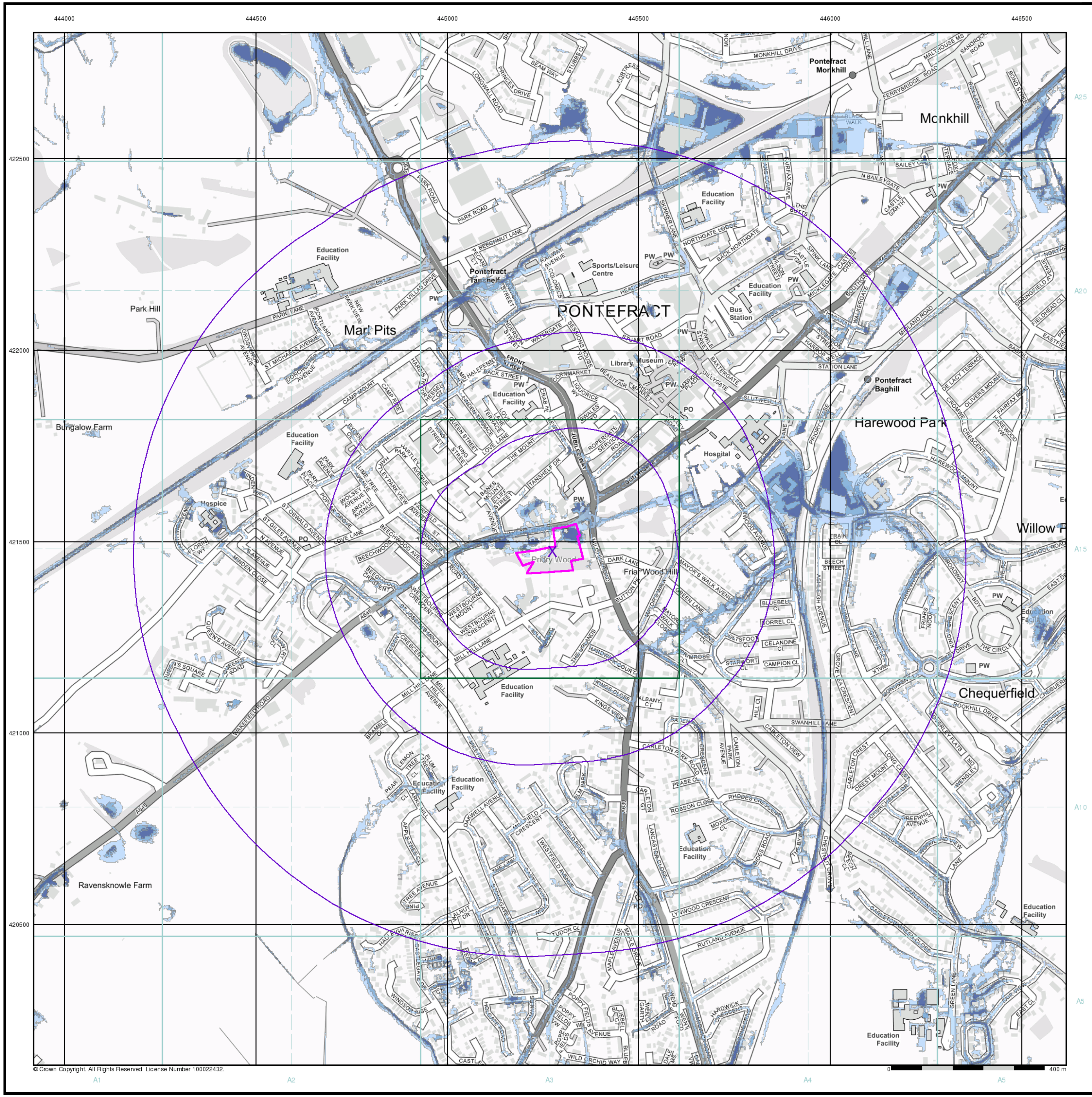


LITHOS CONSULTING

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point

Risk of Flooding from Surface Water

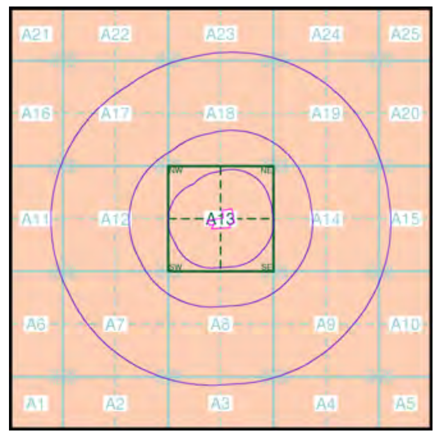
- High - 30 Year Return
- Medium - 100 Year Return
- Low - 1000 Year Return

Suitability

See the suitability map below

- National to county
- County to town
- Town to street
- Street to parcels of land
- Property

EA/NRW Suitability Map - Slice A



N

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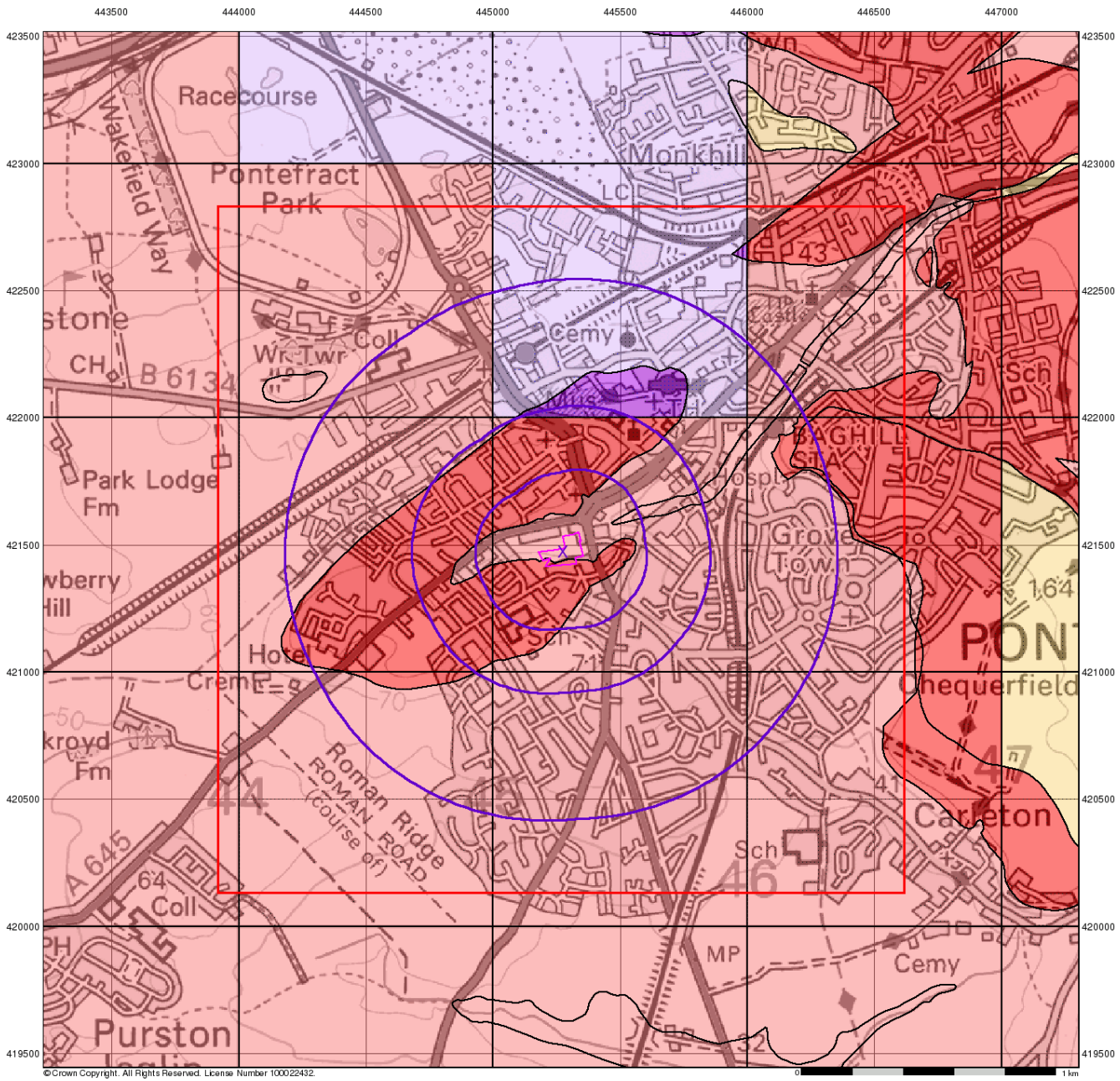
Search Buffer (m): 1000

Site Details

Wakefield Road, Pontefract, West Yorkshire, WF8 4HW

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



LITHOS CONSULTING

Groundwater Vulnerability

General

Specified Site | Specified Buffer(s) | Bearing Reference Point | Slice | Map ID

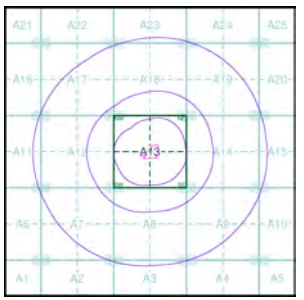
Agency and Hydrological

Bedrock Aquifers	Superficial Aquifers
High Vulnerability, Principal Aquifer	High Vulnerability, Principal Aquifer
High Vulnerability, Secondary Aquifer	High Vulnerability, Secondary Aquifer
Medium Vulnerability, Principal Aquifer	Medium Vulnerability, Principal Aquifer
Medium Vulnerability, Secondary Aquifer	Medium Vulnerability, Secondary Aquifer
Low Vulnerability, Principal Aquifer	Low Vulnerability, Principal Aquifer
Low Vulnerability, Secondary Aquifer	Low Vulnerability, Secondary Aquifer

Unproductive Aquifer

Soluble Rock

Site Sensitivity Context Map - Slice A



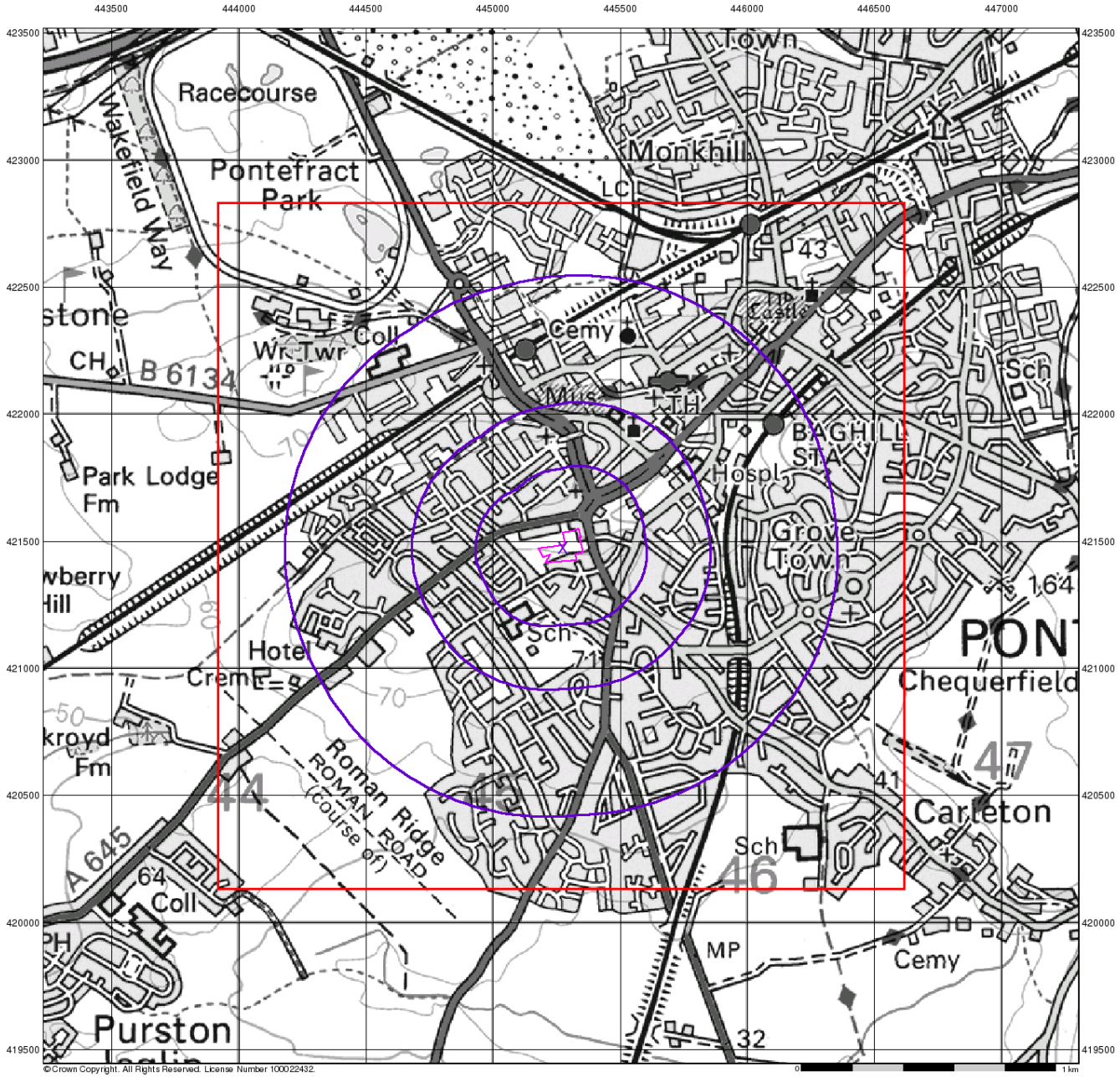
Order Details

Order Number:	286961054_1_1
Customer Ref:	PO18243/JW/3822
National Grid Reference:	445270, 421480
Slice:	A
Site Area (Ha):	1.2
Search Buffer (m):	1000

Site Details

Wakefield Road, Pontefract, West Yorkshire, WF8 4HW

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



LITHOS CONSULTING

Source Protection Zones

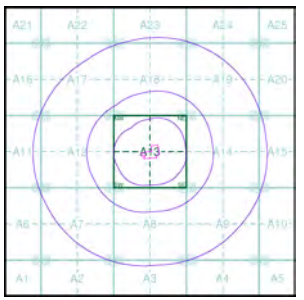
General

Specified Site | Specified Buffer(s) | Bearing Reference Point
Slice | Map ID

Agency and Hydrological

- Inner zone (Zone 1)
- Inner zone - subsurface activity only (Zone 1c)
- Outer zone (Zone 2)
- Outer zone - subsurface activity only (Zone 2c)
- Total catchment (Zone 3)
- Total catchment - subsurface activity only (Zone 3c)
- Special interest (Zone 4)

Site Sensitivity Context Map - Slice A



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GeoReports

British Geological Survey

Julie Wileman
Lithos Consulting Ltd
Parkhill
Walton Road
Wetherby
LS22 5DZ

Natural Ground Stability report:

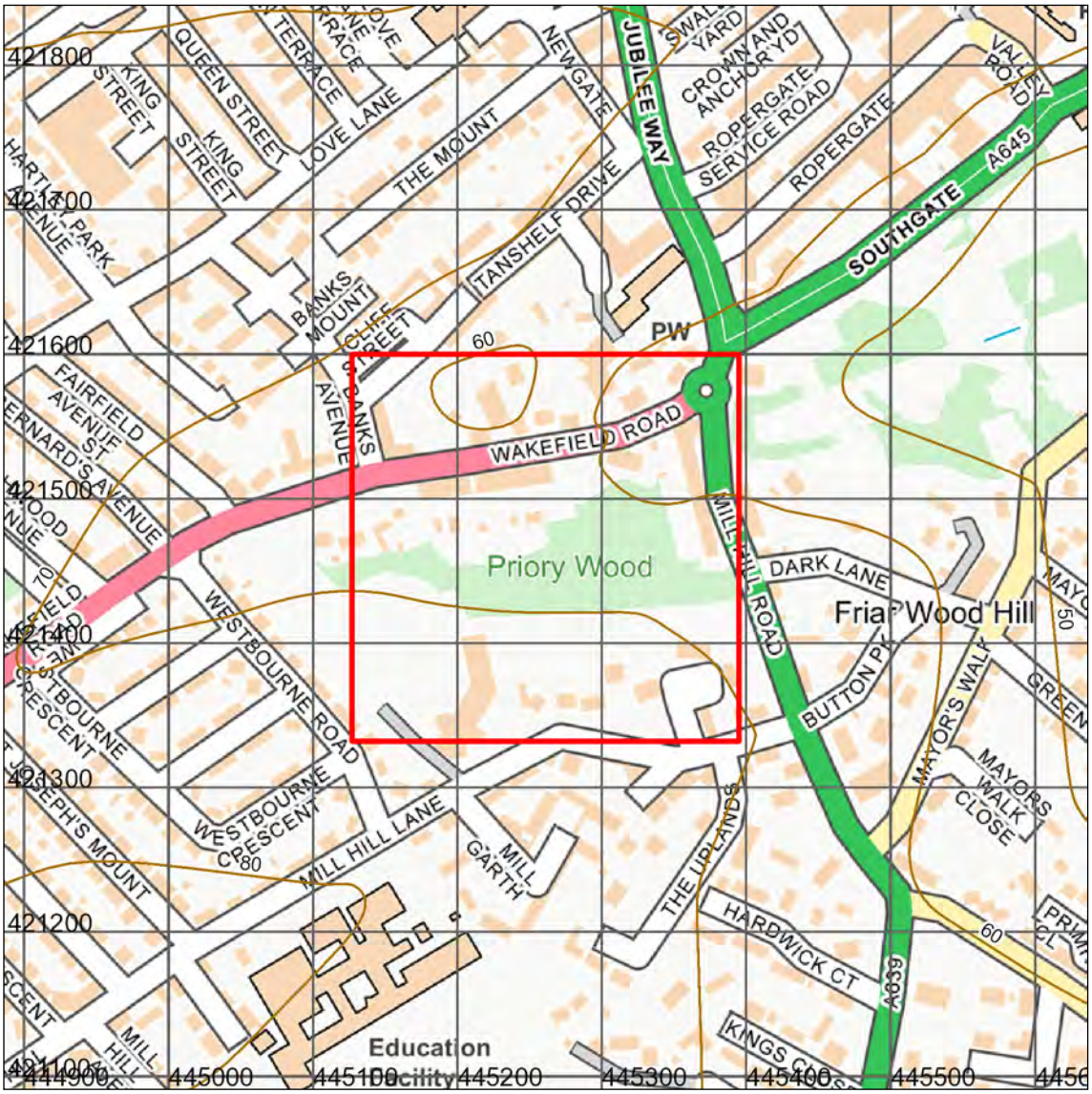
This report briefly describes any natural ground stability hazards ('subsidence') if they are found and gives an indication of their possible severity.

These could include swelling clay, landslip, ground dissolution, running sand, collapsible or compressible ground.

Report Id: ***BGS_321361/27822***

Client reference: PO18245/JW/3822

Search location



Contains OS data © Crown Copyright and database right 2021. OS OpenMap Local: Scale: 1:5 000 (1cm = 50 m)
Search location indicated in red

This report describes a site located at National Grid Reference 445261, 421466. Note that for sites of irregular shape, this point may lie outside the site boundary. Where the client has submitted a site plan the assessment will be based on the area given.

Natural Subsidence Professional Search

This is an indication of the potential for any significant natural subsidence to occur within the extent of the site and a surrounding 50 m buffer zone. It has been generated automatically from BGS's GeoSure dataset, which is based on 1:50 000 scale data. It is designed for use by professionals involved in conveyancing or development of low-rise domestic properties, but it may also be useful for private individuals to help them judge whether or not further professional advice should be sought. We recommend you consult a qualified professional about the search results in this report before making any major decisions based on it.

Definitions

- The **natural geological hazards** included here are shrink-swell, landslides, soluble rocks, compressible ground, collapsible deposits and running sand. Mining related subsidence is not included in this report.
- **Natural subsidence** refers to the propensity for upward, lateral or downward movement of the ground that can be caused by a number of natural geological hazards. Some movements associated with particular hazards may be gradual and of millimetre scale, whilst others may be sudden and of tens of metres in scale.
- **Significant** natural ground instability has the potential to cause damage to some weaker buildings and structures. It should be noted, however, that many buildings, particularly more modern ones, are built to such a standard that they can remain unaffected in areas of significant ground movement.
- Where significant natural ground instability is indicated, its relative **level** of significance is expressed on a scale of C to E ('low' to 'high'), relating to its potential to cause subsidence damage in low-rise buildings.

Limitations:

- This data provides an indication of potential near-surface ground instability related to particular natural geological hazards. It does not give an indication of potential hazards at depth.
- The search does not cover any man-made hazards, such as contaminated land or mining. Searches of coal mining should be carried out via The Coal Authority Mine Reports Service: https://www.gov.uk/check-if-property-is-affected-by-coal-mining
- The scope and accuracy of the results in this report are limited by the methods used to create the GeoSure dataset and may differ from a geologist's interpretation of a wider array of geological information. The answer given should therefore only be treated as indicative for the search area.

- Other more specific and detailed information may be held by BGS for the site, and an assessment of this could result in a modified assessment of ground stability potential. This more detailed assessment is available via other BGS GeoReports.
- The search in this report is carried out for a rectangle or circle (centred on the grid reference or address supplied, using the Ordnance Survey address database) covering the extent of the area of interest. In additional a 50 m buffer is applied which takes into account the spatial accuracy of the underlying data.
- An indication of natural subsidence does not necessarily mean that a location will be affected by ground movement. Such an assessment can be made only by inspection of the building itself by a suitably-qualified professional. Any assessment should take into account a variety of other contributing factors, such as building type and build quality, and nearby vegetation (in particular, the proximity and type of trees).

Search Results:

Important notes

- The term '**search area**' as used throughout this report means the area of interest plus a 50 m buffer zone. The property extent is defined using the original details specified by the client.

Question 1	Answer
Is significant natural ground instability possible in the area?	**YES**

Question 2	Answer
What is the level of hazard on a scale A to E (low to high)? **NOTE: Only levels C, D and E are shown and described below, as Levels A & B are considered insignificant**	**Level C**

Question 3	Answer
Which natural geological hazards could be contributing to the ground instability in the area? *How much ground instability each hazard may cause is indicated by the Level C to E in brackets.*	Sand that can wash away or flow into holes or fissures due to presence of water ('Running Sand') (LEVEL C)

Question 4	Answer
If you are a property owner/buyer what action should be taken?	If natural geological hazards at level C, D or E have been indicated this means there is potential ground instability in your area that may cause some properties to suffer subsidence damage. However, it does not necessarily mean that your property will be affected, and in order to find out if this is the case or not, you should obtain further advice from a qualified expert, such as a building surveyor. Show them this report and ask them to evaluate the property and its surroundings for any signs of existing subsidence damage and for advice on the likelihood for subsidence to occur in the future. The notes at

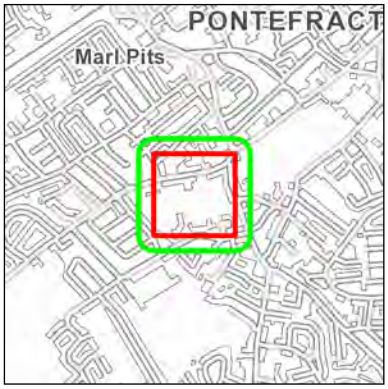
	the end of this report module may be useful in this regard. Note that the type of building and its surroundings (e.g. the presence of trees) are also very important when considering subsidence risk. Many types of properties, particularly newer ones, are well constructed and unlikely to be affected by subsidence, even in areas of significant ground movements.

Question 5	**Answer**
Where could the natural geological hazards occur in the area?	See the maps that follow.

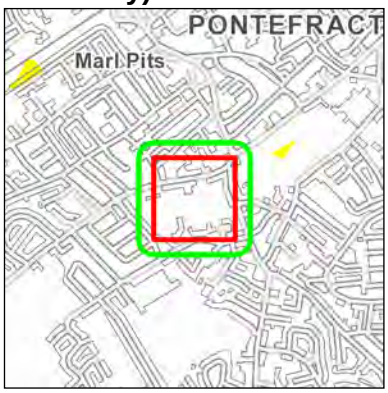
Maps from the GeoSure dataset showing natural subsidence potential

The following maps show where significant natural ground instability at or near the surface could occur in relation to each of six geological hazards. The relative level of potential is indicated in colour and described in the key. Please note that a hazard is reported as significant for the property if it occurs within the specified site or the surrounding buffer zone.

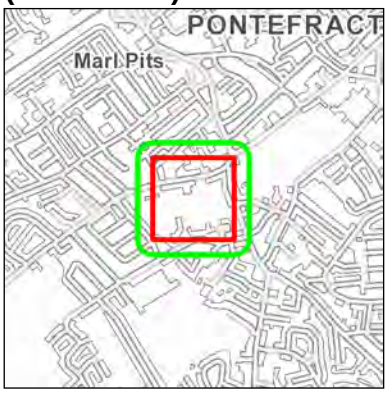
Shrink-Swell



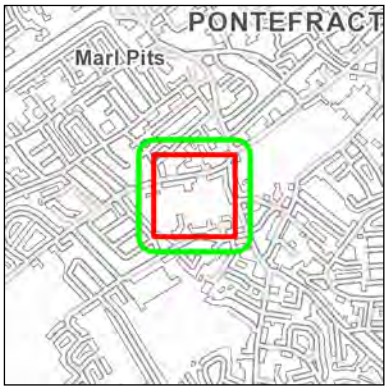
Landslides (slope instability)



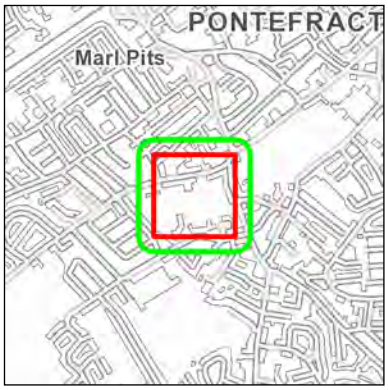
Soluble Rocks (dissolution)



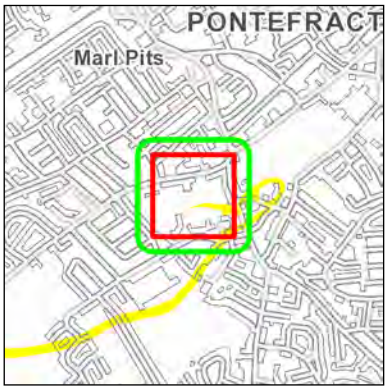
Compressible Ground



Collapsible Deposits



Running Sand



Search area indicated in red

50 m buffer indicated in green

For the key to relative level of potential for natural geological hazards see over the page

The unshaded (white) areas on the map (levels A, B or 'No hazard') represent areas where the conditions that cause natural ground movements due to the six natural geological hazards are considered to be absent or unlikely to be significant.

Key to Shrink-Swell Hazard:

Level	Hazard description	Advice for public	Advice for specialist
C	Ground conditions predominantly medium plasticity.	Do not plant trees with high soil moisture demands near to buildings. Avoid increased infiltration and seek specialist advice before disposing of large amounts of water to the ground through soakaways.	**New build** – Test for plasticity index is recommended. Possible increase in construction cost to remove potential shrink-swell problems. **Existing property** – Possible increase in insurance risk in droughts or where high moisture demand vegetation is present due to shrink-swell clay problems if foundations are not suitable.
D	Ground conditions predominantly high plasticity.	Do not plant or remove trees or shrubs near to buildings without expert advice about their effect and management. Seek specialist advice before disposing of large amounts of water to the ground through soakaways.	**New build** – Test for plasticity index is necessary. Probable increase in construction cost to remove potential shrink-swell problems. **Existing property** – Probable increase in insurance risk in droughts or where high moisture demand vegetation is present due to shrink-swell clay problems if foundations are not suitable.
E	Ground conditions predominantly very high plasticity.	Do not plant or remove trees or shrubs near to buildings without expert advice about their effect and management. Seek specialist advice before disposing of large amounts of water to the ground through soakaways.	**New build** – Test for plasticity index is essential. Definite increase in construction cost to remove potential shrink-swell problems. **Existing property** – Significant increase in insurance risk in droughts or where high moisture demand vegetation is present due to shrink swell clay problems if foundations are not suitable.

Key to Landslides (slope instability) Hazard:

Level	Hazard description	Advice for public	Advice for specialist
C	Slope instability problems may be present or anticipated. Site investigation should consider specifically the slope stability of the site.	Ask about implication for stability if large changes to drainage or excavations take place near to buildings. Seek specialist advice if major changes in ground conditions are likely and before disposing of large amounts of water to the ground through soakaways.	**New build** – Consider possibility of trench side or slope movement during excavations, or consequence of changes to drainage. Possible increase in construction cost to remove potential slope stability problems. **Existing property** – No significant increase in insurance risk due to natural slope instability problems.
D	Slope instability problems are probably present or have occurred in the past. Land use should consider specifically the stability of the site.	Avoid large amounts of water entering the ground through pipe leakage or soakaways without specialist advice. Do not undercut or place large amounts of material on slopes without technical advice.	**New build** – Assess slope stability of site and consequences of excavation, loading and water content changes during and after construction. **Existing property** – Probable increase in insurance risk due to natural slope instability after changes to ground conditions such as a very long, excessively wet winter.
E	Slope instability problems almost certainly present and may be active. Significant constraint on land use.	Seek expert advice about stability of the ground and its management to maintain and increase its stability.	**New build** – Slope stability assessment necessary, special design may be necessary, construction may not be possible. **Existing property** – Significant increase in insurance risk in some cases. Site-specific consideration is necessary to separate cases where landslide s are stabilised or ancient and stable from those that may be active or may fail.

Key to Soluble Rocks (dissolution) Hazard:

Level	Hazard description	Advice for public	Advice for specialist
C	Soluble rocks are present within the ground. Some dissolution features may be present. Potential for difficult ground conditions are at a level where they may be considered; localised subsidence need not be considered except in exceptional circumstances.	Consider implications for stability when changes to surface drainage or new construction are planned. Seek specialist advice before disposing of surface drainage to the adjacent ground.	**New build** – Site investigation should consider potential for dissolution problems on the site and its surroundings. Care should be taken with local drainage into the adjacent bedrock. **Existing property** – Possible increase in insurance risk due to soluble rocks. Some possibility of potential liability due to groundwater pollution may be present.
D	Soluble rocks are present within the ground. Many dissolution features may be present. Potential for difficult ground conditions are at a level where they should be considered. Potential for subsidence is at a level where it may need to be considered.	Consider obtaining specialist advice before loading the land or undertaking building work. Seek specialist advice before disposing of surface drainage to the adjacent ground. Maintain drainage infrastructure.	**New build** – Specialist site investigation and stability assessment may be necessary before construction. Construction work may cause subsidence. Isolate surface drainage from the karst system and groundwater. Increased construction costs are possible. **Existing property** – Possible increase in insurance risk due to soluble rocks. Some possibility of potential liability due to groundwater pollution may be present.
E	Soluble rocks are present within the ground. Numerous dissolution features may be present. Potential for difficult ground conditions should be investigated. Potential for localised subsidence is at a level where it should be considered.	Obtain specialist advice on need for stabilisation work and/or land management plan to maintain stability. Do not dispose of surface drainage into the adjacent ground. Maintain drainage infrastructure.	**New build** – Specialist land stability assessment necessary. Investigation, remediation and/or mitigation works may be necessary to stabilise the area. Construction work may cause subsidence. Isolate surface drainage from the karst system and groundwater. Increased construction costs. **Existing property** – Probable increase in insurance risk due to soluble rocks. Probable potential liability due to groundwater pollution.

Key to Compressible Ground Hazard:

Level	Hazard description	Advice for public	Advice for specialist
C	Compressibility and uneven settlement potential may be present. Land use should consider specifically the compressibility and variability of the site.	Take technical advice regarding settlement when planning extensions to existing property or when retrofitting soakaways.	**New build** – Consider possibility of settlement during construction due to compressible deposits. Unlikely to be increase in construction costs due to potential compressibility problems. **Existing property** – No significant increase in insurance risk due to compressibility problems.
D	Compressibility and uneven settlement hazards are probably present. Land use should consider the compressibility and variability of the site.	Avoid large differential loadings of ground. Do not drain or dewater ground near the property without specialist advice.	**New build** – Assess the variability and bearing capacity of the ground. May need special foundations to avoid excessive settlement during and after construction. Consider effects of changes to drainage regime and groundwater level. Extra construction costs are likely. **Existing property** – Possible increase in insurance risk from compressibility if groundwater levels drop due to drought or dewatering.
E	Highly compressible strata present. Significant constraint on land use depending on thickness.	Avoid large differential loadings of ground. Do not drain or dewater ground near the property without specialist advice.	**New build** – Assess the variability and bearing capacity of the ground. Probably needs special foundations to avoid excessive settlement during and after construction. Consider effects of changes to drainage regime and groundwater level. Construction may not be possible at economic cost. **Existing property** – Probable increase in insurance risk from compressibility due to drought or dewatering unless appropriate foundations are present.

Key to Collapsible Deposits Hazard:

Level	Hazard description	Advice for public	Advice for specialist
C	Deposits with potential to collapse when loaded and saturated are possibly present in places.	Avoid large amounts of water entering the ground through pipe leakage or soakaways without specialist advice. Do not increase loading on existing foundations without technical advice.	Contact local authorities for information on local occurrence of damage due to collapsible ground. **New build** – Assess the possibility of collapsible (loessic) deposits by ground investigation. If present do not exceed safe bearing capacity during or after construction and maintain site drainage, or carry out ground stabilisation. **Existing property** – Possible increase in insurance risk if collapsible deposits are present and if the load on the ground is increased or ground saturated by leakage or localised flooding.
D	Deposits with potential to collapse when loaded and saturated are probably present in places.	Avoid large amounts of water entering the ground through pipe leakage or soakaways without specialist advice. Do not increase loading on existing foundations without technical advice.	Contact local authorities for information on local occurrence of damage due to collapsible deposits. **New build** – Assess the possibility of collapsible deposits by ground investigation. If present do not exceed safe bearing capacity during or after construction and maintain site drainage, or carry out ground stabilisation. **Existing property** – Possible increase in insurance risk if collapsible deposits are present and if the load on the ground is increased or ground saturated by leakage or localised flooding.
E	Deposits with potential to collapse when loaded and saturated have been identified.	Avoid large amounts of water entering the ground through pipe leakage or soakaways. Do not increase loading on existing foundations without technical advice.	Contact local authorities for information on local occurrence of damage due to collapsible ground. **New build** – Assess the possibility of collapsible deposits by ground investigation. If present do not exceed safe bearing capacity during or after construction and maintain site drainage, or carry out ground stabilisation. **Existing property** – Possible increase in insurance risk if collapsible deposits are present and if the load on the ground is increased or ground saturated by leakage or localised flooding.

Key to Running Sand Hazard:

Level	Hazard description	Advice for public	Advice for specialist
C	Running sand conditions may be present. Constraints may apply to land uses involving excavation or the addition or removal of water.	Normal maintenance to avoid leakage of water-bearing services or water bodies (ponds, swimming pools) should avoid any problems due to running sands. Seek specialist advice before disposing of large amounts of water to the ground through soakaways.	**New build** – Consider possibility of running sands into trenches or excavations if water table is high. Avoid concentrated water inputs to site. Unlikely to be increase in construction costs due to potential for running sand problems. **Existing property** – No significant increase in insurance risk due to running sand problems.
D	Running sand conditions are probably present. Constraints may apply to land uses involving excavation or the addition or removal of water.	Avoid large amounts of water entering the ground through pipe leakage or soakaways without specialist advice. Do not dig (deep) holes into saturated ground near the property without technical advice.	**New build** – Assess the need for close-boarded sides to excavations and the consequences of soil and groundwater conditions during and after construction. **Existing property** – Possible increase in insurance risk from running conditions due to service leakage, high rainfall events or localised flooding.
E	Running sand conditions are almost certainly present. Constraints will apply to land uses involving excavation or the addition or removal of water.	Avoid large amounts of water entering the ground through pipe leakage or soakaways without specialist advice. Do not dig (deep) holes into saturated ground without technical advice.	**New build** – Assess the need for close-boarded sides to excavations and the consequences of soil and groundwater conditions during and after construction. Possible extra cost during construction and requirement for basements to be water proofed. **Existing property** – Possible increase in insurance risk from running conditions due to service leakage, high rainfall events or localised flooding.

Question 6	Answer
What is the geology of the area?	Please see the maps below, which show the geology underlying the area. You can compare these to the maps in Question 5 in order to understand the way that the underlying rocks and deposits are related to the potential natural geological hazards.

Geology maps

Geology maps for the area around your site are provided in this section, taken from the 1:50000 BGS Digital Geological Map of Great Britain (BGS Geology 50k). The first two maps show separately the two main components of natural geology that may be present in an area – **superficial deposits** and **bedrock**. The third map, a "combined geology map", shows both layers superimposed.

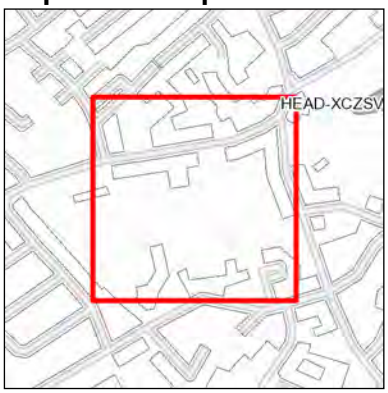
Superficial deposits: These include recent geological deposits, such as river sands and gravels, or glacial deposits, which lie on top of the bedrock in many areas (an alternative term for Superficial deposits is 'Drift Deposits')

Bedrock: Bedrock describes the rocks which underlie the whole of an area, upon which superficial deposits may lie (an alternative term for Bedrock is 'Solid Geology')

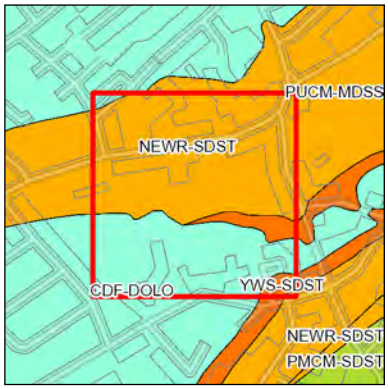
More information about BGS Geology 50k is available here http://www.bgs.ac.uk/products/digitalmaps/DiGMapGB_50.html and information on the BGS geological classification schemes here http://www.bgs.ac.uk/bgsrcs/. The maps are labelled with two-part computer codes that indicate the name of the geological unit and its composition. Descriptions of the units listed in the map keys may be available in the BGS Lexicon of Named Rock Units (http://www.bgs.ac.uk/lexicon/). If available, these descriptions can be found by searching against the first part of the computer code used on the maps. Please consult the legend and the codes on the map in areas of complex geology. If in doubt, please contact BGS Enquiries for clarification.

The geological formations are listed broadly in order of age in the map keys (youngest first) but only to the formation level (a formation is a package of related rocks). Within formations, please be aware that individual members may not be ordered by age.

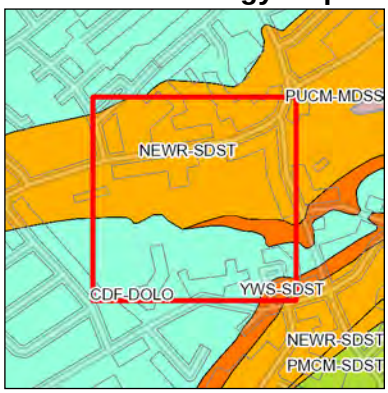
Superficial Deposits



Bedrock



Combined Geology Map



Site location indicated in red

Fault

Coal, ironstone or mineral vein

Note: Faults are shown for illustration and to aid interpretation of the map. Because these maps are generalised from more detailed versions not all such features are shown and their absence on the map face does not necessarily mean that none are present. Coals, ironstone beds and mineral veins occur only in certain rock types and regions of the UK.

Key to Superficial deposits:

Map colour	Computer Code	Rock name	Rock type
	HEAD-XCZSV	HEAD	CLAY, SILT, SAND AND GRAVEL

Key to Bedrock geology:

Map colour	Computer Code	Rock name	Rock type
	CDF-DOLO	CADEBY FORMATION	DOLOSTONE
	YWS-SDST	YELLOW SANDS FORMATION	SANDSTONE
	NEWR-SDST	NEWSTEAD ROCK	SANDSTONE
	PUCM-MDSS	PENNINE UPPER COAL MEASURES FORMATION	MUDSTONE, SILTSTONE AND SANDSTONE
	PMCM-SDST	PENNINE MIDDLE COAL MEASURES FORMATION	SANDSTONE

What do the geological hazards mean?

The answer to Question 3 will have pointed to one or more natural geological hazards in the area. This section provides a brief explanation of these hazards to help you understand what they mean. This includes information on what you should look for in and around the property and what you should and should not do. The hazard is only reported below if it is shown as significant within the search area.

RUNNING SAND HAZARD

What is running sand?
Running sand occurs when loosely-packed sand becomes fluidised by water flowing through the spaces between the grains. The pressure of the flowing water reduces the contact between the grains and they are swept along in the flow. This may happen where springs occur at the base of sand outcrops, where excavations in sand go below the water table, around leaking drains or mains water supply pipes or in entire sand bodies if vibrated (liquefaction) e.g. by an earthquake

Why does running sand cause a hazard?
If sand below a building runs it may remove support and the building may sink below the surface of the surrounding ground or relative to adjacent structures. If the running sand is due to a minor water flow such as a leaking pipe it may form a void or remove support from below a part of the building which may cause cracking of floors and/or walls due to differential settlement. Sands may also run where excavations in sand go below the water table.

What problems does running sand cause?
Running sand may cause:-

- access paths and roads to be broken and disrupted
- service connections to water, gas and electricity supplies to break.
- structural damage to foundations and to the fabric of the building if uneven sinking occurs under the foundations.

What might I see?
Changes in ground surface level relative to the building.
Depressions in the ground surface along pipe runs
Cracks at the junction of a building and paths or roads leading from it.
Water leaks from service connections.
Tilting of walls or buildings.
Cracks within the fabric of the building.
Cracks at the junction of a building and associated structures (eg walls or outbuildings) physically joined to the building.

What action should I take?
If running sand appears to be happening on or near your property, inform your insurance company, mortgage lender, landlord or get specialist advice from a suitably qualified expert such as a chartered engineering geologist, geotechnical engineer or structural surveyor.
If active running sand is not happening but the ground has a potential for running sand being present this should be taken into account before designing new buildings

or changes to land use.

DO
Take specialist advice before starting major building work
Maintain water pipes and drains in good condition (no leaks).

DO NOT
Dispose of rain or surface water to soak-aways near buildings.
Dig holes below the water table near buildings.

Contact Details

Keyworth Office
British Geological Survey
Environmental Science Centre
Nicker Hill
Keyworth
Nottingham
NG12 5GG
Tel: 0115 9363143
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Report issued by
BGS Enquiry Service

Appendix F

Trial Pit Logs

LITHOS CONSULTING

Trial Pit Log

Trialpit No **TP01**

Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445209.00 - 421462.00 Level:	Date 10/11/2021
Location: Pontefract		Dimensions (m): 2 × 0.6, Depth 3.50	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.20	J&T		0.10			MADE GROUND: Dark grey and black very gravelly fine to coarse SAND. Gravel is fine to coarse subangular to angular brick fragments and sandstone. (GRANULAR MADE GROUND)
				0.60			MADE GROUND: Light brown mottled dark brown very sandy fine to coarse subangular to angular GRAVEL of sandstone, brick, concrete, ceramic, plastic and metal with high cobbles content. Cobbles are angular brick, concrete and sandstone. (GRANULAR MADE GROUND)
	0.80	J&T					MADE GROUND: Light brown very gravelly fine to coarse SAND with high cobble content. Gravel is fine to coarse subangular to subrounded brick, concrete sandstone and glass. Cobbles are angular brick, concrete and sandstone. (QUARRY BACKFILL)
	2.70	J&T		2.60			MADE GROUND: Soft to firm dar grey and dark brown slightly gravelly sandy CLAY with medium cobble content. Gravel is fine to medium subangular to subrounded sandstone and brick. Cobbles are angular brick. (QUARRY BACKFILL)
	2.80	D					
				3.50			End of pit at 3.50 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 0.5m and 3.5m depth during excavation.

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LITHOS CONSULTING

Trial Pit Log

Trialpit No
TP02
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445455.00 - 421447.00 Level:	Date 10/11/2021
Location: Pontefract		Dimensions (m): 2 × 0.6, Depth 3.00	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.60	J,K&T		0.90			MADE GROUND: Dark grey mottled brown slightly clayey sandy fine to coarse subangular to angular GRAVEL of brick, glass, wood, plastic, concrete and metal with high cobble content. Cobbles are angular brick, concrete, metal and plastic. (Approx. 20% brick, 10% plastic, 10% other) (GRANULAR MADE GROUND)
	2.00	J&T		3.00			MADE GROUND: Black and dark brown sandy fine to coarse subangular to angular GRAVEL of brick, concrete and glass with high cobble content. Cobbles are angular brick and concrete. (Aprrox. 30% brick, 20% concrete) (QUARRY BACKFILL) End of pit at 3.00 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 0.5m and 3.0m depth during excavation.

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Trial Pit Log

Trialpit No **TP03**

Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445248.00 - 421451.00 Level:	Date 10/11/2021
Location: Pontefract		Dimensions (m): 2 × 0.6, Depth 3.50	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.40	J&T		0.40			MADE GROUND: Brown and light brown very gravelly fine to coarse SAND with medium cobble content. Gravel is fine to coarse subangular to subrounded sandstone, brick, concrete, plastic and metal. Cobbles are angular concrete and brick. (GRANULAR MADE GROUND)
	2.00	J&T					MADE GROUND: Firm dark brown sandy very gravelly CLAY with high cobble content. Gravel is fine to coarse subangular to subrounded brick, pot, metal, plasticand concrete. Cobbles are angular brick and concrete. (Approx. 20% brick, 20% concrete, 10% other) (QUARRY BACKFILL)
				3.50			End of pit at 3.50 m

1 2 3 4 5

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit remained stable during excavation.

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Trial Pit Log

Trialpit No
TP04
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445247.00 - 421466.00 Level:	Date 10/11/2021
Location: Pontefract		Dimensions (m): 2 × 0.6, Depth 3.00	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.50	J&T					MADE GROUND: Dark brown very sandy fine to coarse subangular to rubrounded GRAVEL of brick, concrete, plastic, glass and metal with high cobble content. Cobbles are angular brick and concrete. (Approx. 35% brick, 20% concrete, 5% other) (QUARRY BACKFILL)
	1.00	J&T					
							Below 2.0m - Approx. 50% brick, 20% concrete.
				3.00			End of pit at 3.00 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 1.0m and 2.5m depth during excavation with complete collapse at 2.5m.

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Trial Pit Log

Trialpit No
TP05
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445286.00 - 421509.00 Level:	Date 10/11/2021
Location: Pontefract		Dimensions (m): 2 × 0.6 Depth 2.00	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.30	J&T		0.50			MADE GROUND: Dark grey and black very sandy fine to coarse subangular to angular GRAVEL of brick, concrete and sandstone with high cobble content. (GRANULAR MADE GROUND)
				2.00			Light brown very sandy fine to coarse subangular to angular GRAVEL of sandstone with high cobble content. Cobbles are angular sandstone. (YELLOW SANDS FORMATION) End of pit at 2.00 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 1.2m and 2.0m depth during excavation.

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Trial Pit Log

Trialpit No
TP06
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445333.00 - 421515.00 Level:	Date 10/11/2021
Location: Pontefract		Dimensions (m): 2 × 0.6, Depth 1.30	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.50	J&T		0.60			MADE GROUND: Brown very gravelly SAND with medium cobble content. Gravel is fine to coarse subangular to angular brick, sandstone and concrete. Cobbles are angular brick, sandstone and concrete. (Approx. 10% brick, 10% concrete) (GRANULAR MADE GROUND)
				1.30			Reddish Brown and yellow brown SANDSTONE recovered as sandy tabular gravel of sandstone. (NEWSTEAD ROCK) *From 1.3m - Difficult to excavate.* End of pit at 1.30 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 0.8m and 1.3m depth during excavation.

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Trial Pit Log

Trialpit No **TP07**

Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445308.00 - 421519.00 Level:	Date 10/11/2021
Location: Pontefract		Dimensions (m): 2 × 0.6, Depth 1.20	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.20	J&T		0.10			Tarmac (TARMAC)
				0.40			MADE GROUND: Light brown very sandy fine to coarse subangular to angular GRAVEL of sandstone and brick. (GRANULAR MADE GROUND)
							Light brown SANDSTONE recovered as sandy tabular subangular to angular gravel and cobbles of sandstone. (YELLOW SANDS FORMATION)
							From 1.2m - Difficult to excavate.
				1.20			End of pit at 1.20 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 0.8m and 1.2m depth during excavation.

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Trial Pit Log

Trialpit No **TP08**

Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445305.00 - 421479.00 Level:	Date 10/11/2021
Location: Pontefract		Dimensions (m): 2 × 0.6, Depth 2.70	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10 - 0.30	B		0.20			Soft dark brown slightly sandy CLAY. Gravel is fine to coarse subangular to subrounded sandstone. (TOPSOIL)
	0.40	D					Light brown gravelly very clayey fine to coarse SAND. Gravel is fine to coarse subangular to angular sandstone. (YELLOW SANDS FORMATION)
				1.20			Light brown SANDSTONE recovered as sandy tabular subangular to angular gravel and cobbles of sandstone. (YELLOW SANDS FORMATION)
	1.60	T					
				2.70			*From 2.6m - Complete collapse* End of pit at 2.70 m

1 2 3 4 5

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 1.2m and 2.7m depth during excavation with complete collapse at 2.7m.

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Trial Pit Log

Trialpit No
TP09
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445293.00 - 421485.00 Level:	Date 10/11/2021
Location: Pontefract		Dimensions (m): 2 × 0.6 Depth 2.00	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.10			Soft dark brown slightly sandy CLAY. Gravel is fine to coarse subangular to subrounded sandstone. (TOPSOIL)
	0.50 - 1.00	B					Light brown SANDSTONE recovered as sandy tabular subangular to angular gravel and cobbles of sandstone. (YELLOW SANDS FORMATION)
	0.70	T					
				2.00			End of pit at 2.00 m

1
2
3
4
5

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 1.0m and 2.0m depth during excavation with complete collapse at 2.0m.

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Trial Pit Log

Trialpit No
TP10
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445263.00 - 421477.00 Level:	Date 10/11/2021
Location: Pontefract		Dimensions (m): 2 × 0.6 Depth 3.00	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.10			MADE GROUND: Black Slightly gravelly fine SAND. Gravel is fine to medium subangular to anglar tarmac and concrete. (GRANULAR MADE GROUND)
	0.40	J&T					MADE GROUND: Dark brown and light brown gravelly SAND with medium cobble content. Gravel is fine to coarse subangular to rounded sandstone, brick and concrete. Cobbles are angular brick and concrete. (Approx. 15% brick, concrete and metal) (QUARRY BACKFILL)
							From 3.0m - Difficult to excavate.
				3.00			End of pit at 3.00 m

1
2
3
4
5

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 1.0m and 3.0m depth during excavation.

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Trial Pit Log

Trialpit No **TP11**

Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445230.00 - 421461.00 Level:	Date 10/11/2021
Location: Pontefract		Dimensions (m): 2 × 0.6, Depth 1.80	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.20			MADE GROUND: Dark grey and reddish brown fine to coarse subangular to angular GRAVEL and COBBLES of brick and concrete. (GRANULAR MADE GROUND)
	0.40	J&T		0.60			MADE GROUND: Dark brown sandy fine to coarse subangular to subrounded GRAVEL of brick, concrete and tarmac with high cobble content. Cobbles are angular brick and concrete. (QUARRY BACKFILL)
	0.80	T					Light brown SANDSTONE recovered as sandy tabular subangular to angular gravel and cobbles of sandstone. (YELLOW SANDS FORMATION)
				1.80			*Below 1.8m - Difficult to excavate.* End of pit at 1.80 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 0.6m and 1.8m depth during excavation.

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Trial Pit Log

Trialpit No
TP12
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445213.00 - 421471.00 Level:	Date 10/11/2021
Location: Pontefract		Dimensions (m): 2 × 0.6, Depth 3.30	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.50	J&T					MADE GROUND: Dark brown and dark grey very sandy fine to coarse subangular to angular GRAVEL of brick, concrete and metal with high cobble content. Cobbles are angular brick and concrete. (Approx. 20% brick, 10% concrete, 10% other) (QUARRY BACKFILL)
	1.20	J&T					*From 1.5m - Aprrox. 10% brick, 5% concrete, 5% other.*
							Below 3.0m - Frequent sandstone boulder.
							Below 3.2m - Difficult to excavate.
				3.30			End of pit at 3.30 m

1
2
3
4
5

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 1.5m and 3.3m depth during excavation.

AGS

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Trial Pit Log

Trialpit No
TP101E
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445280.04 - 421477.32 Level:	Date 10/02/2022
Location: Pontefract		Dimensions (m): 15 × 0.6 Depth 2.00	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.30			Dark brown slightly gravelly fine to coarse SAND. Gravel is fine to coarse subangular to angular brick and sandstone. (GRANULAR MADE GROUND)
							Yellowish brown very gravelly SAND. Gravel is fine to coarse subangular to angular SANDSTONE. (YELLOW SANDS FORMATION)
				2.00			End of pit at 2.00 m

1 2 3 4 5

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit remained stable during excavation.

AGS

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Trial Pit Log

Trialpit No
TP101W
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445268.12 - 421475.58 Level:	Date 10/02/2022
Location: Pontefract		Dimensions (m): 15 × 0.6 Depth 2.00	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.30			Dark brown slightly gravelly fine to coarse SAND. Gravel is fine to coarse subangular to angular brick and sandstone. (GRANULAR MADE GROUND)
				1.00			Dark brown mottled light brown gravelly fine to coarse SAND. Gravel is fine to coarse subangular to angular brick and sandstone. (QUARRY BACKFILL)
				2.00			Yellowish brown very gravelly SAND. Gravel is fine to coarse subangular to angular SANDSTONE. (YELLOW SANDS FORMATION) End of pit at 2.00 m

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 1.0m and 2.0m depth during excavation.

AGS

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Trial Pit Log

Trialpit No
TP102E
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445280.04 - 421459.38 Level:	Date 10/02/2022
Location: Pontefract		Dimensions (m): 8 × 0.6, Depth 2.00	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.20			Dark brown slightly gravelly fine to coarse SAND. Gravel is fine to coarse subangular to angular brick and sandstone. (GRANULAR MADE GROUND)
							Yellowish brown very gravelly SAND. Gravel is fine to coarse subangular to angular SANDSTONE. (YELLOW SANDS FORMATION)
				2.00			End of pit at 2.00 m

1 2 3 4 5

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit remained stable during excavation.

AGS

LITHOS CONSULTING

Trial Pit Log

Trialpit No
TP102W
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445268.12 - 421457.64 Level:	Date 10/02/2022
Location: Pontefract		Dimensions (m): 8 × 0.6, Depth 2.50	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.20			Dark brown slightly gravelly fine to coarse SAND. Gravel is fine to coarse subangular to angular brick and sandstone. (GRANULAR MADE GROUND)
							Dark brown mottled light brown gravelly fine to coarse SAND. Gravel is fine to coarse subangular to angular brick and sandstone. (QUARRY BACKFILL)
				2.50			End of pit at 2.50 m

1
2
3
4
5

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit were unstable between 0.2m and 2.0m depth during excavation.

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Trial Pit Log

Trialpit No
TP103
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445199.00 - 421450.68 Level:	Date 10/02/2022
Location: Pontefract		Dimensions (m): 4 × 0.6 Depth 3.50	Scale 1:25
Client: Frontline Estates Ltd			Logged WN

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.20			Dark brown slightly gravelly fine to coarse SAND. Gravel is fine to coarse subangular to angular brick and sandstone. (GRANULAR MADE GROUND)
				1.00			Vrown very sandy fine to coarse subangular to angular GRAVEL of brick and sandstone with high cobble content. Cobbles are brick and sandstone. (QUARRY BACKFILL)
				2.50			Light brown very gravelly SAND. Gravel is fine to coarse subangular to angular SANDSTONE. (Easy to excavate - Possibly reworked/infilled from quarry works) (REWORKED NATURAL MATERIAL)
				3.50			Yellowish brown very gravelly SAND. Gravel is fine to coarse subangular to angular SANDSTONE. (YELLOW SANDS FORMATION)
							End of pit at 3.50 m

1 2 3 4 5

Remarks: 1. Prior to excavation a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during excavation. 3. Backfilled with materials arising upon completion. 4. Co-ordinates from hand held GPS, hole not surveyed in.

Stability: 1. The sides of the trial pit remained stable during excavation.

AGS

Appendix G

Borehole Logs

LITHOS CONSULTING

Borehole Log

Borehole No. **BH01**

Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445211.29 - 421458.29	Hole Type CP
Location: Pontefract		Level:	Scale 1:50
Client: Frontline Estates Ltd		Dates: 09/02/2022 - 09/02/2022	Logged By WN

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.30			Dark brown and black gravelly fine to coarse SAND. Gravel is fine to coarse subangular to subrounded brick and concrete. (GRANULAR MADE GROUND)
		1.00		N=3 (1,1/0,1,1,1)				Very loose to loose Dark brown sandy clayey fine to coarse subangular to angular GRAVEL of brick, concrete and sandstone with high cobble content. Cobbles are brick and concrete. (QUARRY BACKFILL)
		2.00		N=3 (1,1/1,1,1,0)				
		3.00		N=5 (2,1/1,1,1,2)				
		4.00		N=5 (1,1/1,1,1,2)				
		5.00		N=4 (1,1/1,1,1,1)				
					5.40			Light bown mottled grey slightly clayey gravelly fine to coarse SAND. Gravel is fine to coarse subangular to rounded sandstone. Rare brick fragments. (QUARRY BACKFILL)
		6.00		N=9 (2,3/3,2,2,2)	5.80			Loose to medium dense slightly gravelly fine to coarse SAND with frequent dark grey sandy clay inclusions. Gravel is fine to coarse subrounded to rounded cemented sandstone. (Possibly reworked natural material infilled from quarry works) (REWORKED NATURAL MATERIAL)
		7.00		N=17 (3,3/4,6,4,3)				
		8.00		N=4 (1,2/1,1,1,1)				
		9.00		50 (2,2/50 for 260mm)				
					9.40			No sample recovery. Assumed very dense SANDSTONE. (NEWSTEAD ROCK)
					9.50			*At 9.4m - Chiselling for 30 minutes, advancing 100mm.* End of borehole at 9.50 m

Remarks

1. Prior to drilling a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during drilling. 3. The borehole was advanced by chiselling from 9.4m to 9.5m (0.5 hrs). 4. Co-ordinates from hand held GPS, hole not surveyed in.

AGS

LITHOS CONSULTING

Borehole Log

Borehole No.
BH02
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445242.50 - 421455.37	Hole Type CP
Location: Pontefract		Level:	Scale 1:50
Client: Frontline Estates Ltd		Dates: 11/02/2022 - 11/02/2022	Logged By WN

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
		1.00		N=3 (1,0/1,0,1,1)				Very loose dark brown sandy clayey fine to coarse subangular to angular GRAVEL of brick, concrete and sandstone with high cobble content. Cobbles are brick and concrete. (QUARRY BACKFILL)
		2.00		N=5 (2,3/2,1,1,1)				
		3.00		N=0 (0,0/0,0,0,0)				
					3.30			
		4.00		N=19 (4,3/3,6,5,5)				Medium dense light bown mottled grey slightly clayey gravelly fine to coarse SAND. Gravel is fine to coarse subangular to rounded sandstone. Rare brick fragments. (QUARRY BACKFILL)
					4.30			
		5.00		N=27 (2,3/7,4,7,9)				Light brown highly weathered SANDSTONE recovered as medium dense slightly gravelly fine to coarse SAND. Gravel is fine to coarse subrounded to rounded cemented sandstone. (Possibly reworked/infilled from quarry works) (YELLOW SANDS FORMATION)
		5.50		N=23 (3,4/5,5,6,7)				
		6.00		50 (25 for 40mm/50 for 55mm)	6.00			End of borehole at 6.00 m

Remarks
1. Prior to drilling a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during drilling. 3. The borehole was advanced by chiselling from 6.0m to 6.05m (0.5 hrs). 4. Co-ordinates from hand held GPS, hole not surveyed in.

AGS

LITHOS CONSULTING

Borehole Log

Borehole No.
BH03
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445262.11 - 421468.77	Hole Type CP
Location: Pontefract		Level:	Scale 1:50
Client: Frontline Estates Ltd		Dates: 10/02/2022 - 10/02/2022	Logged By WN

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.10			Dark brown and black gravelly fine to coarse SAND. Gravel is fine to coarse subangular to subrounded brick and concrete. (GRANULAR MADE GROUND)
		1.00		N=8 (2,3/2,2,2,2)				Loose to medium dense dark brown sandy clayey fine to coarse subangular to angular GRAVEL of brick, concrete and sandstone with high cobble content. Cobbles are brick and concrete. (QUARRY BACKFILL)
		2.00		N=9 (3,4/2,3,2,2)				
		3.00		N=17 (3,5/5,4,3,5)				
		4.00		N=18 (3,3/3,3,5,7)	4.00			Light brown highly weathered SANDSTONE recovered as medium dense slightly gravelly fine to coarse SAND. Gravel is fine to coarse subrounded to rounded cemented sandstone. (Possibly reworked/infilled from quarry works) (YELLOW SANDS FORMATION)
		4.80		50 (25 for 30mm/50 for 45mm)	4.80			End of borehole at 4.80 m

Remarks
1. Prior to drilling a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during drilling. 3. The borehole was advanced by chiselling from 4.8m to 4.83m (0.5 hrs). 4. Co-ordinates from hand held GPS, hole not surveyed in.

AGS

LITHOS CONSULTING

Borehole Log

Borehole No.
BH04
Sheet 1 of 1

Project Name: Wakefield Road	Project No. 3822	Co-ords: 445288.22 - 421479.01	Hole Type CP
Location: Pontefract		Level:	Scale 1:50
Client: Frontline Estates Ltd		Dates: 11/02/2022 - 11/02/2022	Logged By WN

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.30			Dark brown and black gravelly fine to coarse SAND. Gravel is fine to coarse subangular to subrounded brick and concrete. (GRANULAR MADE GROUND)
		1.00		N=4 (2,2/1,1,1,1)				Light brown highly weathered SANDSTONE recovered as medium dense slightly gravelly fine to coarse SAND. Gravel is fine to coarse subrounded to rounded cemented sandstone. (YELLOW SANDS FORMATION)
		2.00		N=13 (3,3/3,4,3,3)				
		3.00		N=27 (3,4/7,12,5,3)	3.00			End of borehole at 3.00 m

Remarks
1. Prior to drilling a Cable Avoidance Tool (CAT) survey was carried out. 2. Groundwater was not apparent during drilling. 3. Co-ordinates from hand held GPS, hole not surveyed in.

AGS

Appendix H

Contaminated land assessment for selection of water supply pipes

Contaminated Land Assessment Form

Introduction

In January 2011, UK Water Industry Research (UKWIR) published “Guidance for the selection of Water Supply Pipes to be used in Brownfield Sites” (UKWIR 2010 Ref 10/WM/03/21). The aim of this publication is to ensure that the correct materials are selected for Water Pipes to be used below ground in Brownfield Sites. It supersedes the Water Regulations Advisory Scheme (WRAS) Information and Guidance Note 9-04-03 “Laying Pipes in Contaminated Land” which has now been withdrawn.

The UKWIR guidance is for use by Water Companies, Self Lay Organisations, Developers and Consultants during the planning, designing and construction of water mains and/or services in Brownfield Sites. The guidance defines a Brownfield Site as “Land or premises that have not previously been used or developed. They may also be vacant or derelict. However, they are not necessarily contaminated.” UKWIR state the guidance does not apply to Greenfield Sites, however YW reserve the right to apply relevant sections of the publication to Greenfield Sites that may potentially be contaminated.

Contamination Risk Assessment

Please complete the form below to allow us to assess the risk of contamination of the drinking water supply from chemicals within the soil. Yorkshire Water now lays all its water mains and service pipes in plastic. Many organic compounds (i.e. Phenols, Fuels and other hydrocarbons) can either permeate through the walls of plastic pipes into the water supply or dissolve and weaken the pipe causing water leaks.

As a minimum a desk top study (Preliminary Risk Assessment) shall be provided to YW that sets out whether the land through which the Water Pipes are to be laid may be affected by contamination. For those sites where land contamination may be present, appropriate testing shall be undertaken on existing ground materials and remediated materials. The testing requirements are as described below:

Testing Requirements

The tests that are required on all sites where the potential for contamination has been established through the desk top study and where water pipes are proposed to be laid must be undertaken by bodies with accreditation from UKAS (United Kingdom Accreditation Service) and where possible MCERTS (Environment Agency’s Monitoring Certification Service).

The tests on soil/water samples shall be those to detect and report on the levels of the following contaminant groups and chemical characteristics: **VOC’s, SVOC’s, Mineral Oil compounds C10-C40, Conductivity, pH** and **Redox potential** (as stipulated in the UKWIR guidance Appendix G).
If the previous function of the site involved the use, storage, manufacture or disposal of any of the following elements, appropriate testing for these substances will be required:

Ethers, Nitrobenzene, Ketones, Aldehydes and Amines. Please note UKWIR guidance states the presence of Amines on any site precludes the use of Polyethylene pipework.

Sufficiency of Testing

Samples taken must be representative of the soil conditions in which the Water Pipes are proposed to be laid (normally Water Pipes are laid at a depth between 0.7m and 1.3m below finished ground level). As a result samples must be taken at least 500mm below the base of the proposed pipe where the proposed location is known. If the proposed location is unknown then samples must be taken at intervals between the surface level and 1.5m from below finished ground level as a minimum. Where appropriate groundwater sampling and groundwater monitoring will also be necessary (see UKWIR guidance).

Further guidance on representative sampling is contained within BS10175:2011 “Code of practice for the Investigation of Potentially Contaminated Sites”.

The table in section 3 lists the contaminants and their respective levels which can permeate or damage plastic water pipes with consequent risk to the water supply. Where soil analysis results indicate levels of these contaminants above the maximum allowable concentration shown, then Yorkshire Water will determine that all mains and service pipes are laid in suitable materials resistant to the risks posed by those contaminants. Where sites have been used for any of the activities listed in Section 2 all mains and services shall be laid in suitable permeation resistant pipe systems due to the high risk of these contaminants being present.

Health & Safety Assessment

The UKWIR guidance does not cover Health & Safety considerations as part of any operational activities undertaken on Brownfield Sites. In order to maintain the safety of our staff, service partners and customers YW will also assess the site based on the EA CLEA (Contaminated Land Exposure Assessment) guidelines.

In order to comply with Yorkshire Water’s Health & safety requirements please review the following information relating to trigger values for Health & Safety considerations when laying Water Pipes in contaminated Land.

	Contaminant	Mg/Kg		Contaminant	Mg/Kg
Inorganic	Arsenic	32	Organic	Benzene	0.33
	Nickel	130		Toulene	610
	Mercury	170		Ethylbenzene	350
	Selenium	35		Xylene	230
	Cadmium	10		Phenol	420

Contaminants highlighted green tested for with results below the Trigger Values above. Contaminants highlighted red are tested for with results above the Trigger Values above, see below for more details.
Contaminants in black not tested for as no potential source identified on the Conceptual Site Model.

One elevated concentration of Arsenic (49mg/kg) was encountered in TP05. Elevated concentrations of Copper (500mg/kg in TP05), Lead (elevated concentrations ranging from 200mg/kg to 1100mg/kg in 7 trial pits) and Zinc (elevated concentrations ranging from 200mg/kg to 3650mg/kg in 3 trial pits) were also encountered.

1. Your Details

Company Name	Contact Name
Lithos Consulting	Charlotte Copley

Site Address	Contact Number
Wakefield Road, Pontefract	01937 545 335

2. The Previous Use of the Site

Please indicate below the previous uses of the site being developed

The site comprises a parcel of overgrown vegetation with some derelict and partially demolished buildings. The site has remained relatively unchanged throughout its history with a priory located in the northeast corner and the remainder of the site covered by woodland. During ground investigation, backfilled quarry materials (sandy gravel of brick, concrete and sandstone) were encountered across the majority of the site to depths in excess of 3.5m.

Please indicate if the site (or part of it) has previously been used for any of the following activities:

No	Chemicals Manufacture	No	Paint or Ink Manufacture
No	Explosives / Ordnance Manufacture	No	Railway Land / Railway Engineering
No	Fuel Filling Stations / Storage	No	Scrap metals
No	Metal Finishing / Treating	No	Shipbuilding & Repair
No	Mechanical Engineering Works	No	Vehicle Repair Garages
No	Oil & Gas Refineries / Storage	No	Vehicle Manufacturing

3. Contaminants

Please complete the table below with the highest concentrations in mg/kg of each or any of the contaminants listed. The information should be extracted from your soil reports already undertaken, if any of the contaminants were not tested for, this should be declared on the form along with the reasons for this. If you have any difficulty interpreting the results of your soil sample analyses and transposing them into the table, then you should consult the body who undertook the sampling and reporting. If there are more than 3 sample locations with associated test results please copy the table for each location and label each with the sample reference and its location on a site plan.

Laboratory Name:		Date	Concentration	
Group No.	Parameter group	Unit	Depth (m)	Detection Limit
1	Extended VOC suite (with TIC)	mg/kg	Not tested	0.5
1a	BTEX & MTBE	mg/kg	Not tested	0.1
2	Extended SVOC suite (with TIC)	mg/kg	Not tested	2
2e	Phenols	mg/kg	Not tested	2
2f	Cresols and chlorinated phenols	mg/kg	Not tested	2
3	Mineral Oils C_{11}-C_{20}	mg/kg	<30	10
4	Mineral Oils C_{21}-C_{40}	mg/kg	<20	500
5	Corrosive (Conductivity, Redox & pH)		Not tested	
	Conductivity	µS/cm	Not tested	
	Redox	Volt	Not tested	
	pH	pH	pH between 8.0 & 10.6	
2a	Ethers	mg/kg	Not tested	0.5
2b	Nitrobenzene	mg/kg	Not tested	0.5
2c	Ketones	mg/kg	Not tested	0.5
2d	Aldehydes	mg/kg	Not tested	0.5
6	Amines	mg/kg	Not tested	Any presence

DO NOT include a copy of your soil report with your application, if you do not complete the table above your application will be returned to you.

No sources of the above potential contaminants identified on the Conceptual Site Model, therefore no testing undertaken

Please include a site plan highlighting the locations of the above sample points.

Drawing 3822/6 shows the locations of exploratory holes.

4. Remediation of the site

Please indicate below any remediation work that will be undertaken on the site to remove / mitigate the effect of any contaminants identified in the soil report. Please include the nature and depth of any remediation work.

Topsoil and Granular Made Ground contained elevated concentration of inorganic contaminants in addition to relatively minor amounts of asbestos, consequently, it is recommended that this material is placed beneath 600mm clean cover in areas of gardens and POS. Turnover of top 2m of made ground also recommended to remove obstructions.

5. Can I use plastic pipe if I undertake remediation works?

Yes, as long as the remediation work either removes the contaminated soil or reduces the level of contaminants below trigger levels. Moving contaminated material so that it is under roads and footpaths is not acceptable as this is the likely location of the water mains.

As water mains are lad to a depth of 0.9m to the top of the pipe, any contaminated soil to a depth of 1.3m must be removed. We will require post remediation sampling results confirming contamination has fallen below the trigger levels prior to releasing any works to our Service Partners.

If contamination is found all water mains and services on the site must be laid in a suitable barrier pipe. Yorkshire Water will not change the agreed mains material after the agreement has been signed by all parties. So please ensure your remediation proposals are made clear at this stage.

6. Declaration

I hereby confirm that the information provided in this form is true and I understand that should the site conditions change from those indicated in this report that I may incur additional costs.

Your Signature	Date
CC	23rd February 2022

Your Name & Title (PLEASE PRINT	Role in organisation
C Copley	Engineer

Please return this completed form with your application to Developer Services, Yorkshire Water Services Ltd, PO Box 52, Bradford BD3 7YD

References

BS10175:2011 “Investigation of Potentially Contaminated Sites Code of Practice

UK Water Industry Research (UKWIR) “ Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites” (Ref 10/WM/03/21)

Appendix I

Chemical Results

Certificate of Analysis

Certificate Number	21-24344	*Issued:*	23-Nov-21

Client Lithos Consulting Ltd
Parkhill
Walton Rd
Wetherby
LS22 5DZ

Our Reference	21-24344
Client Reference	3822
Order No	P018317
Contract Title	Wakefield Road
Description	20 Soil samples.
Date Received	15-Nov-21
Date Started	15-Nov-21
Date Completed	23-Nov-21
Test Procedures	Identified by prefix DETSn (details on request).

Notes Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Approved By

Adam Fenwick
Contracts Manager

UKAS TESTING
2139

Summary of Chemical Analysis
Soil Samples

Our Ref 21-24344
Client Ref 3822
Contract Title Wakefield Road

			Lab No	1934497	1934498	1934499	1934500	1934501	1934502
			.Sample ID	TP01	TP02	TP05	TP06	TP07	TP01
			Depth	0.20	0.60	0.30	0.50	0.20	0.80
			Other ID						
			Sample Type	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
			Sampling Date	10/11/2021	10/11/2021	10/11/2021	10/11/2021	10/11/2021	10/11/2021
			Sampling Time	n/s	n/s	n/s	n/s	n/s	n/s
Test	**Method**	**LOD**	**Units**						
Preparation									
Stones >10mm	DETSC 1003*	1	% m/m	43	47	24	18	17	26
Moisture Content	DETSC 1004	0.1	%	13	23	20	11	12	14
Metals									
Arsenic	DETSC 2301#	0.2	mg/kg	6.1	12	49	8.9	20	17
Boron, Water Soluble	DETSC 2311#	0.2	mg/kg	1.4	1.3	0.7	0.5	0.4	0.7
Cadmium	DETSC 2301#	0.1	mg/kg	0.3	0.6	0.2	0.1	0.1	0.3
Chromium	DETSC 2301#	0.15	mg/kg	320	14	29	7.9	9.5	35
Chromium III	DETSC 2301*	0.15	mg/kg	320	14	29	7.9	9.5	35
Chromium, Hexavalent	DETSC 2204*	1	mg/kg	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper	DETSC 2301#	0.2	mg/kg	35	110	500	20	44	50
Lead	DETSC 2301#	0.3	mg/kg	25	200	270	47	210	170
Mercury	DETSC 2325#	0.05	mg/kg	< 0.05	1.2	0.18	0.11	0.18	0.17
Nickel	DETSC 2301#	1	mg/kg	9.3	14	39	11	16	14
Selenium	DETSC 2301#	0.5	mg/kg	2.6	0.6	1.2	< 0.5	< 0.5	< 0.5
Vanadium	DETSC 2301#	0.8	mg/kg	200	21	76	18	47	34
Zinc	DETSC 2301#	1	mg/kg	49	360	110	36	44	110
Inorganics									
pH	DETSC 2008#		pH	10.6	9.2	9.7	8.1	8.7	9.5
Total Organic Carbon	DETSC 2084#	0.5	%	6.2	5.1	8.0	1.2	2.6	1.9
Sulphate Aqueous Extract as SO4	DETSC 2076#	10	mg/l		1600				
Petroleum Hydrocarbons									
EPH (C6-C10)	DETSC 3321*	0.1	mg/kg		< 0.1				
EPH (C10-C12)	DETSC 3311	10	mg/kg		< 10				
EPH (C12-C16)	DETSC 3311	10	mg/kg		< 10				
EPH (C16-C21)	DETSC 3311	10	mg/kg		< 10				
EPH (C21-C35)	DETSC 3311	10	mg/kg		< 10				
EPH (C35-C40)	DETSC 3311	10	mg/kg		< 10				
EPH (C10-C40)	DETSC 3311#	10	mg/kg		< 10				

Key: * -not accredited. # -MCERTS (accreditation only applies if report carries the MCERTS logo). n/s -not supplied.

Summary of Chemical Analysis
Soil Samples

Our Ref 21-24344
Client Ref 3822
Contract Title Wakefield Road

			Lab No	1934497	1934498	1934499	1934500	1934501	1934502
			.Sample ID	TP01	TP02	TP05	TP06	TP07	TP01
			Depth	0.20	0.60	0.30	0.50	0.20	0.80
			Other ID						
			Sample Type	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
			Sampling Date	10/11/2021	10/11/2021	10/11/2021	10/11/2021	10/11/2021	10/11/2021
			Sampling Time	n/s	n/s	n/s	n/s	n/s	n/s
Test	**Method**	**LOD**	**Units**						
PAHs									
Naphthalene	DETSC 3303#	0.03	mg/kg	0.06	< 0.03	0.07	< 0.03	< 0.03	0.06
Acenaphthylene	DETSC 3303#	0.03	mg/kg	0.11	< 0.03	0.18	< 0.03	0.08	< 0.03
Acenaphthene	DETSC 3303#	0.03	mg/kg	0.73	< 0.03	0.15	< 0.03	< 0.03	0.08
Fluorene	DETSC 3303	0.03	mg/kg	0.42	< 0.03	0.12	< 0.03	< 0.03	0.06
Phenanthrene	DETSC 3303#	0.03	mg/kg	5.5	0.11	1.1	0.05	0.15	0.86
Anthracene	DETSC 3303	0.03	mg/kg	2.1	< 0.03	0.40	< 0.03	0.08	0.20
Fluoranthene	DETSC 3303#	0.03	mg/kg	28	0.29	6.2	0.13	0.60	1.6
Pyrene	DETSC 3303#	0.03	mg/kg	28	0.27	7.1	0.12	0.71	1.4
Benzo(a)anthracene	DETSC 3303#	0.03	mg/kg	11	0.13	4.0	0.07	0.38	0.58
Chrysene	DETSC 3303	0.03	mg/kg	13	0.14	4.0	0.07	0.47	0.60
Benzo(b)fluoranthene	DETSC 3303#	0.03	mg/kg	14	0.14	6.9	0.08	1.1	0.59
Benzo(k)fluoranthene	DETSC 3303#	0.03	mg/kg	6.1	0.06	2.1	< 0.03	0.37	0.23
Benzo(a)pyrene	DETSC 3303#	0.03	mg/kg	11	0.12	6.5	0.06	1.1	0.47
Indeno(1,2,3-c,d)pyrene	DETSC 3303#	0.03	mg/kg	6.4	0.06	4.3	< 0.03	1.1	0.22
Dibenzo(a,h)anthracene	DETSC 3303#	0.03	mg/kg	1.9	< 0.03	1.4	< 0.03	0.33	0.06
Benzo(g,h,i)perylene	DETSC 3303#	0.03	mg/kg	7.2	0.06	6.2	0.04	1.6	0.26
PAH - USEPA 16, Total	DETSC 3303	0.1	mg/kg	140	1.4	51	0.61	8.0	7.3

Key: * -not accredited. # -MCERTS (accreditation only applies if report carries the MCERTS logo). n/s -not supplied.

Summary of Chemical Analysis
Soil Samples

Our Ref 21-24344
Client Ref 3822
Contract Title Wakefield Road

	Lab No	1934503	1934504	1934505	1934506	1934507	1934508
	.Sample ID	TP01	TP02	TP03	TP03	TP04	TP04
	Depth	2.70	2.00	0.40	2.00	0.50	1.00
	Other ID						
	Sample Type	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampling Date	10/11/2021	10/11/2021	10/11/2021	10/11/2021	10/11/2021	10/11/2021
	Sampling Time	n/s	n/s	n/s	n/s	n/s	n/s
Test	**Method**	**LOD**	**Units**				
Preparation							
Stones >10mm	DETSC 1003*	1	% m/m	< 1.0	11	< 1.0	< 1.0	38	31
Moisture Content	DETSC 1004	0.1	%	18	20	20	26	15	21
Metals							
Arsenic	DETSC 2301#	0.2	mg/kg	10	24	19	25	12	20
Boron, Water Soluble	DETSC 2311#	0.2	mg/kg	1.4	1.6	0.9	1.2	1.0	1.2
Cadmium	DETSC 2301#	0.1	mg/kg	0.3	0.5	3.7	0.3	0.4	0.2
Chromium	DETSC 2301#	0.15	mg/kg	7.0	20	19	21	12	10
Chromium III	DETSC 2301*	0.15	mg/kg	7.0	20	19	21	12	10
Chromium, Hexavalent	DETSC 2204*	1	mg/kg	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper	DETSC 2301#	0.2	mg/kg	18	78	48	61	45	48
Lead	DETSC 2301#	0.3	mg/kg	44	610	350	170	590	1100
Mercury	DETSC 2325#	0.05	mg/kg	0.11	0.60	0.26	0.14	0.16	0.29
Nickel	DETSC 2301#	1	mg/kg	10	20	25	28	12	15
Selenium	DETSC 2301#	0.5	mg/kg	< 0.5	< 0.5	0.9	1.3	< 0.5	< 0.5
Vanadium	DETSC 2301#	0.8	mg/kg	15	31	43	43	20	25
Zinc	DETSC 2301#	1	mg/kg	55	260	120	80	120	78
Inorganics							
pH	DETSC 2008#		pH	8.6	8.1	8.0	8.1	8.8	9.1
Total Organic Carbon	DETSC 2084#	0.5	%	2.6	6.7	6.5	7.0	3.9	6.0
Sulphate Aqueous Extract as SO4	DETSC 2076#	10	mg/l		510		100		22
Petroleum Hydrocarbons							
EPH (C6-C10)	DETSC 3321*	0.1	mg/kg						
EPH (C10-C12)	DETSC 3311	10	mg/kg						
EPH (C12-C16)	DETSC 3311	10	mg/kg						
EPH (C16-C21)	DETSC 3311	10	mg/kg						
EPH (C21-C35)	DETSC 3311	10	mg/kg						
EPH (C35-C40)	DETSC 3311	10	mg/kg						
EPH (C10-C40)	DETSC 3311#	10	mg/kg						

Key: * -not accredited. # -MCERTS (accreditation only applies if report carries the MCERTS logo). n/s -not supplied.

Summary of Chemical Analysis
Soil Samples

Our Ref 21-24344
Client Ref 3822
Contract Title Wakefield Road

			Lab No	1934503	1934504	1934505	1934506	1934507	1934508
			.Sample ID	TP01	TP02	TP03	TP03	TP04	TP04
			Depth	2.70	2.00	0.40	2.00	0.50	1.00
			Other ID						
			Sample Type	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
			Sampling Date	10/11/2021	10/11/2021	10/11/2021	10/11/2021	10/11/2021	10/11/2021
			Sampling Time	n/s	n/s	n/s	n/s	n/s	n/s
Test	**Method**	**LOD**	**Units**						
PAHs									
Naphthalene	DETSC 3303#	0.03	mg/kg	< 0.03	< 0.03	< 0.03	< 0.03	0.07	< 0.03
Acenaphthylene	DETSC 3303#	0.03	mg/kg	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Acenaphthene	DETSC 3303#	0.03	mg/kg	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Fluorene	DETSC 3303	0.03	mg/kg	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Phenanthrene	DETSC 3303#	0.03	mg/kg	< 0.03	0.31	0.13	0.03	0.23	0.10
Anthracene	DETSC 3303	0.03	mg/kg	< 0.03	0.09	< 0.03	< 0.03	0.06	< 0.03
Fluoranthene	DETSC 3303#	0.03	mg/kg	0.09	0.62	0.15	0.05	0.23	0.13
Pyrene	DETSC 3303#	0.03	mg/kg	0.08	0.56	0.13	0.05	0.20	0.11
Benzo(a)anthracene	DETSC 3303#	0.03	mg/kg	0.04	0.21	0.05	< 0.03	0.08	0.06
Chrysene	DETSC 3303	0.03	mg/kg	0.04	0.22	0.06	< 0.03	0.08	0.06
Benzo(b)fluoranthene	DETSC 3303#	0.03	mg/kg	0.05	0.19	0.05	< 0.03	0.07	0.07
Benzo(k)fluoranthene	DETSC 3303#	0.03	mg/kg	< 0.03	0.08	< 0.03	< 0.03	< 0.03	0.03
Benzo(a)pyrene	DETSC 3303#	0.03	mg/kg	0.04	0.15	0.04	< 0.03	0.05	0.06
Indeno(1,2,3-c,d)pyrene	DETSC 3303#	0.03	mg/kg	< 0.03	0.06	< 0.03	< 0.03	< 0.03	< 0.03
Dibenzo(a,h)anthracene	DETSC 3303#	0.03	mg/kg	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Benzo(g,h,i)perylene	DETSC 3303#	0.03	mg/kg	< 0.03	0.07	< 0.03	< 0.03	< 0.03	< 0.03
PAH - USEPA 16, Total	DETSC 3303	0.1	mg/kg	0.35	2.6	0.62	0.10	1.1	0.60

Key: * -not accredited. # -MCERTS (accreditation only applies if report carries the MCERTS logo). n/s -not supplied.

Summary of Chemical Analysis
Soil Samples

Our Ref 21-24344
Client Ref 3822
Contract Title Wakefield Road

	Lab No	1934509	1934510	1934511	1934512	1934513	1934514
	.Sample ID	TP10	TP11	TP12	TP12	TP08	TP08
	Depth	0.40	0.40	0.50	1.20	0.40	1.60
	Other ID						
	Sample Type	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampling Date	10/11/2021	10/11/2021	10/11/2021	10/11/2021	10/11/2021	10/11/2021
	Sampling Time	n/s	n/s	n/s	n/s	n/s	n/s
Test	**Method**	**LOD**	**Units**				
Preparation							
Stones >10mm	DETSC 1003*	1	% m/m	8.0	14	17	15		
Moisture Content	DETSC 1004	0.1	%	15	15	17	18		
Metals							
Arsenic	DETSC 2301#	0.2	mg/kg	9.6	16	11	8.5		
Boron, Water Soluble	DETSC 2311#	0.2	mg/kg	1.2	0.8	1.0	0.9		
Cadmium	DETSC 2301#	0.1	mg/kg	0.5	0.7	0.4	0.2		
Chromium	DETSC 2301#	0.15	mg/kg	9.3	15	13	12		
Chromium III	DETSC 2301*	0.15	mg/kg	9.3	15	13	12		
Chromium, Hexavalent	DETSC 2204*	1	mg/kg	< 1.0	< 1.0	< 1.0	< 1.0		
Copper	DETSC 2301#	0.2	mg/kg	30	46	31	27		
Lead	DETSC 2301#	0.3	mg/kg	66	150	91	57		
Mercury	DETSC 2325#	0.05	mg/kg	0.09	0.22	0.15	0.13		
Nickel	DETSC 2301#	1	mg/kg	13	21	11	10		
Selenium	DETSC 2301#	0.5	mg/kg	< 0.5	< 0.5	0.7	< 0.5		
Vanadium	DETSC 2301#	0.8	mg/kg	19	26	25	28		
Zinc	DETSC 2301#	1	mg/kg	84	200	80	59		
Inorganics							
pH	DETSC 2008#		pH	8.1	9.3	8.3	8.3	8.1	8.2
Total Organic Carbon	DETSC 2084#	0.5	%	6.0	3.7	5.5	3.8		
Sulphate Aqueous Extract as SO4	DETSC 2076#	10	mg/l	480		19		< 10	< 10
Petroleum Hydrocarbons							
EPH (C6-C10)	DETSC 3321*	0.1	mg/kg						
EPH (C10-C12)	DETSC 3311	10	mg/kg						
EPH (C12-C16)	DETSC 3311	10	mg/kg						
EPH (C16-C21)	DETSC 3311	10	mg/kg						
EPH (C21-C35)	DETSC 3311	10	mg/kg						
EPH (C35-C40)	DETSC 3311	10	mg/kg						
EPH (C10-C40)	DETSC 3311#	10	mg/kg						

Key: * -not accredited. # -MCERTS (accreditation only applies if report carries the MCERTS logo). n/s -not supplied.

Summary of Chemical Analysis
Soil Samples

Our Ref 21-24344
Client Ref 3822
Contract Title Wakefield Road

			Lab No	1934509	1934510	1934511	1934512	1934513	1934514
			.Sample ID	TP10	TP11	TP12	TP12	TP08	TP08
			Depth	0.40	0.40	0.50	1.20	0.40	1.60
			Other ID						
			Sample Type	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
			Sampling Date	10/11/2021	10/11/2021	10/11/2021	10/11/2021	10/11/2021	10/11/2021
			Sampling Time	n/s	n/s	n/s	n/s	n/s	n/s
Test	**Method**	**LOD**	**Units**						
PAHs									
Naphthalene	DETSC 3303#	0.03	mg/kg	0.36	0.52	0.30	0.16		
Acenaphthylene	DETSC 3303#	0.03	mg/kg	0.07	0.10	0.12	0.05		
Acenaphthene	DETSC 3303#	0.03	mg/kg	0.47	0.14	0.27	0.11		
Fluorene	DETSC 3303	0.03	mg/kg	0.37	0.18	0.31	0.12		
Phenanthrene	DETSC 3303#	0.03	mg/kg	2.9	1.2	3.0	1.8		
Anthracene	DETSC 3303	0.03	mg/kg	0.46	0.27	0.72	0.60		
Fluoranthene	DETSC 3303#	0.03	mg/kg	2.9	1.9	5.0	4.5		
Pyrene	DETSC 3303#	0.03	mg/kg	2.6	1.7	4.4	4.1		
Benzo(a)anthracene	DETSC 3303#	0.03	mg/kg	0.99	0.86	1.9	1.6		
Chrysene	DETSC 3303	0.03	mg/kg	1.3	0.97	2.0	1.7		
Benzo(b)fluoranthene	DETSC 3303#	0.03	mg/kg	1.5	1.0	1.9	1.6		
Benzo(k)fluoranthene	DETSC 3303#	0.03	mg/kg	0.42	0.31	0.75	0.50		
Benzo(a)pyrene	DETSC 3303#	0.03	mg/kg	1.5	0.75	1.6	1.2		
Indeno(1,2,3-c,d)pyrene	DETSC 3303#	0.03	mg/kg	0.87	0.35	0.77	0.48		
Dibenzo(a,h)anthracene	DETSC 3303#	0.03	mg/kg	0.25	0.12	0.23	0.16		
Benzo(g,h,i)perylene	DETSC 3303#	0.03	mg/kg	1.1	0.45	0.92	0.60		
PAH - USEPA 16, Total	DETSC 3303	0.1	mg/kg	18	11	24	19		

Key: * -not accredited. # -MCERTS (accreditation only applies if report carries the MCERTS logo). n/s -not supplied.

Summary of Chemical Analysis
Soil Samples

Our Ref 21-24344
Client Ref 3822
Contract Title Wakefield Road

			Lab No	1934515	1934516
			.Sample ID	TP09	TP11
			Depth	0.70	0.80
			Other ID		
			Sample Type	SOIL	SOIL
			Sampling Date	10/11/2021	10/11/2021
			Sampling Time	n/s	n/s
Test	**Method**	**LOD**	**Units**		
Preparation					
Stones >10mm	DETSC 1003*	1	% m/m		
Moisture Content	DETSC 1004	0.1	%		
Metals					
Arsenic	DETSC 2301#	0.2	mg/kg		
Boron, Water Soluble	DETSC 2311#	0.2	mg/kg		
Cadmium	DETSC 2301#	0.1	mg/kg		
Chromium	DETSC 2301#	0.15	mg/kg		
Chromium III	DETSC 2301*	0.15	mg/kg		
Chromium, Hexavalent	DETSC 2204*	1	mg/kg		
Copper	DETSC 2301#	0.2	mg/kg		
Lead	DETSC 2301#	0.3	mg/kg		
Mercury	DETSC 2325#	0.05	mg/kg		
Nickel	DETSC 2301#	1	mg/kg		
Selenium	DETSC 2301#	0.5	mg/kg		
Vanadium	DETSC 2301#	0.8	mg/kg		
Zinc	DETSC 2301#	1	mg/kg		
Inorganics					
pH	DETSC 2008#		pH	8.2	8.6
Total Organic Carbon	DETSC 2084#	0.5	%		
Sulphate Aqueous Extract as SO4	DETSC 2076#	10	mg/l	11	29
Petroleum Hydrocarbons					
EPH (C6-C10)	DETSC 3321*	0.1	mg/kg		
EPH (C10-C12)	DETSC 3311	10	mg/kg		
EPH (C12-C16)	DETSC 3311	10	mg/kg		
EPH (C16-C21)	DETSC 3311	10	mg/kg		
EPH (C21-C35)	DETSC 3311	10	mg/kg		
EPH (C35-C40)	DETSC 3311	10	mg/kg		
EPH (C10-C40)	DETSC 3311#	10	mg/kg		

Key: * -not accredited. # -MCERTS (accreditation only applies if report carries the MCERTS logo). n/s -not supplied.

Summary of Chemical Analysis
Soil Samples

Our Ref 21-24344
Client Ref 3822
Contract Title Wakefield Road

Lab No	1934515	1934516
.Sample ID	TP09	TP11
Depth	0.70	0.80
Other ID		
Sample Type	SOIL	SOIL
Sampling Date	10/11/2021	10/11/2021
Sampling Time	n/s	n/s

Test	Method	LOD	Units		
PAHs					
Naphthalene	DETSC 3303#	0.03	mg/kg		
Acenaphthylene	DETSC 3303#	0.03	mg/kg		
Acenaphthene	DETSC 3303#	0.03	mg/kg		
Fluorene	DETSC 3303	0.03	mg/kg		
Phenanthrene	DETSC 3303#	0.03	mg/kg		
Anthracene	DETSC 3303	0.03	mg/kg		
Fluoranthene	DETSC 3303#	0.03	mg/kg		
Pyrene	DETSC 3303#	0.03	mg/kg		
Benzo(a)anthracene	DETSC 3303#	0.03	mg/kg		
Chrysene	DETSC 3303	0.03	mg/kg		
Benzo(b)fluoranthene	DETSC 3303#	0.03	mg/kg		
Benzo(k)fluoranthene	DETSC 3303#	0.03	mg/kg		
Benzo(a)pyrene	DETSC 3303#	0.03	mg/kg		
Indeno(1,2,3-c,d)pyrene	DETSC 3303#	0.03	mg/kg		
Dibenzo(a,h)anthracene	DETSC 3303#	0.03	mg/kg		
Benzo(g,h,i)perylene	DETSC 3303#	0.03	mg/kg		
PAH - USEPA 16, Total	DETSC 3303	0.1	mg/kg		

Summary of Asbestos Analysis
Soil Samples

Our Ref 21-24344
Client Ref 3822
Contract Title Wakefield Road

Lab No	Sample ID	Material Type	Result	Comment*	Analyst
1934497	TP01 0.20	SOIL	NAD	none	Lee Kerridge
1934498	TP02 0.60	SOIL	NAD	none	Lee Kerridge
1934499	TP05 0.30	SOIL	NAD	none	Lee Kerridge
1934500	TP06 0.50	SOIL	NAD	none	Lee Kerridge
1934501	TP07 0.20	SOIL	NAD	none	Lee Kerridge
1934502	TP01 0.80	SOIL	NAD	none	Lee Kerridge
1934503	TP01 2.70	SOIL	NAD	none	Lee Kerridge
1934504	TP02 2.00	SOIL	Amosite	Amosite present in small bundle	Lee Kerridge
1934505	TP03 0.40	SOIL	NAD	none	Lee Kerridge
1934506	TP03 2.00	SOIL	NAD	none	Lee Kerridge
1934507	TP04 0.50	SOIL	NAD	none	Lee Kerridge
1934508	TP04 1.00	SOIL	NAD	none	Lee Kerridge
1934509	TP10 0.40	SOIL	NAD	none	Lee Kerridge
1934510	TP11 0.40	SOIL	NAD	none	Lee Kerridge
1934511	TP12 0.50	SOIL	NAD	none	Lee Kerridge
1934512	TP12 1.20	SOIL	NAD	none	Lee Kerridge
1934513	TP08 0.40	SOIL	NAD	none	Lee Kerridge
1934514	TP08 1.60	SOIL	NAD	none	Lee Kerridge
1934515	TP09 0.70	SOIL	NAD	none	Lee Kerridge
1934516	TP11 0.80	SOIL	NAD	none	Lee Kerridge

Crocidolite = Blue Asbestos, Amosite = Brown Asbestos, Chrysotile = White Asbestos. Anthophyllite, Actinolite and Tremolite are other forms of Asbestos. Samples are analysed by DETSC 1101 using polarised light microscopy in accordance with HSG248 and documented in-house methods. NAD = No Asbestos Detected. Where a sample is NAD, the result is based on analysis of at least 2 sub-samples and should be taken to mean 'no asbestos detected in sample'. Key: * -not included in laboratory scope of accreditation.

Information in Support of the Analytical Results

Our Ref 21-24344
Client Ref 3822
Contract Wakefield Road

Containers Received & Deviating Samples

Lab No	Sample ID	Date Sampled	Containers Received	Holding time exceeded for tests	Inappropriate container for tests
1934497	TP01 0.20 SOIL	10/11/21	GJ 250ml		
1934498	TP02 0.60 SOIL	10/11/21	GJ 250ml, GJ 60ml, PT 1L		
1934499	TP05 0.30 SOIL	10/11/21	GJ 250ml, PT 1L		
1934500	TP06 0.50 SOIL	10/11/21	GJ 250ml, PT 1L		
1934501	TP07 0.20 SOIL	10/11/21	GJ 250ml, PT 1L		
1934502	TP01 0.80 SOIL	10/11/21	GJ 250ml, PT 1L		
1934503	TP01 2.70 SOIL	10/11/21	GJ 250ml, PT 1L		
1934504	TP02 2.00 SOIL	10/11/21	GJ 250ml, PT 1L		
1934505	TP03 0.40 SOIL	10/11/21	GJ 250ml, PT 1L		
1934506	TP03 2.00 SOIL	10/11/21	GJ 250ml, PT 1L		
1934507	TP04 0.50 SOIL	10/11/21	GJ 250ml, PT 1L		
1934508	TP04 1.00 SOIL	10/11/21	GJ 250ml, PT 1L		
1934509	TP10 0.40 SOIL	10/11/21	GJ 250ml, PT 1L		
1934510	TP11 0.40 SOIL	10/11/21	GJ 250ml, PT 1L		
1934511	TP12 0.50 SOIL	10/11/21	GJ 250ml, PT 1L		
1934512	TP12 1.20 SOIL	10/11/21	GJ 250ml, PT 1L		
1934513	TP08 0.40 SOIL	10/11/21	PT 1L		
1934514	TP08 1.60 SOIL	10/11/21	PT 1L		
1934515	TP09 0.70 SOIL	10/11/21	PT 1L		
1934516	TP11 0.80 SOIL	10/11/21	PT 1L		

Key: G-Glass J-Jar P-Plastic T-Tub

DETS cannot be held responsible for the integrity of samples received whereby the laboratory did not undertake the sampling. In this instance samples received may be deviating. Deviating Sample criteria are based on British and International standards and laboratory trials in conjunction with the UKAS note 'Guidance on Deviating Samples'. All samples received are listed above. However, those samples that have additional comments in relation to hold time, inappropriate containers etc are deviating due to the reasons stated. This means that the analysis is accredited where applicable, but results may be compromised due to sample deviations. If no sampled date (soils) or date+time (waters) has been supplied then samples are deviating. However, if you are able to supply a sampled date (and time for waters) this will prevent samples being reported as deviating where specific hold times are not exceeded and where the container supplied is suitable.

Soil Analysis Notes

Inorganic soil analysis was carried out on a dried sample, crushed to pass a 425µm sieve, in accordance with BS1377.

Organic soil analysis was carried out on an 'as received' sample. Organics results are corrected for moisture and expressed on a dry weight basis.

The Loss on Drying, used to express organics analysis on an air dried basis, is carried out at a temperature of 28°C +/-2°C.

Disposal

From the issue date of this test certificate, samples will be held for the following times prior to disposal :-

Soils - 1 month, Liquids - 2 weeks, Asbestos (test portion) - 6 months

End of Report

Certificate of Analysis

Certificate Number 21-25624 *Issued:* 06-Dec-21

Client Lithos Consulting Ltd
Parkhill
Walton Rd
Wetherby
LS22 5DZ

Our Reference 21-25624

Client Reference 3822

Order No P018317

Contract Title Wakefield Road

Description One Soil sample.

Date Received 15-Nov-21

Date Started 02-Dec-21

Date Completed 06-Dec-21

Test Procedures Identified by prefix DETSn (details on request).

Notes Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Approved By

Adam Fenwick
Contracts Manager

UKAS TESTING
2139

Summary of Asbestos Analysis

Samples

Our Ref 21-25624
Client Ref 3822
Contract Title Wakefield Road

Lab No	Sample ID	Sample Location	Material Type	Result	Comment*	Analyst

Crocidolite = Blue Asbestos, Amosite = Brown Asbestos, Chrysotile = White Asbestos. Anthophyllite, Actinolite and Tremolite are other forms of Asbestos. Samples are analysed by DETSC 1101 using polarised light microscopy in accordance with HSG248 and documented in-house methods. NAD = No Asbestos Detected. Where a sample is NAD, the result is based on analysis of at least 2 sub-samples and should be taken to mean 'no asbestos detected in sample'. Key: * -not included in laboratory scope of accreditation.

Summary of Asbestos Quantification Analysis
Soil Samples

Our Ref 21-25624
Client Ref 3822
Contract Title Wakefield Road

Lab No	1941822
.Sample ID	TP02
Depth	2.00
Other ID	
Sample Type	
Sampling Date	10/11/2021
Sampling Time	

Test	**Method**	**Units**	
Total Mass% Asbestos (a+b+c)	DETSC 1102	Mass %	**< 0.001**
Gravimetric Quantification (a)	DETSC 1102	Mass %	na
Detailed Gravimetric Quantification (b)	DETSC 1102	Mass %	<0.001
Quantification by PCOM (c)	DETSC 1102	Mass %	na
Potentially Respirable Fibres (d)	DETSC 1102	Fibres/g	na
Breakdown of Gravimetric Analysis (a)			
Mass of Sample		g	650.56
ACMs present*		type	
Mass of ACM in sample		g	
% ACM by mass		%	
% asbestos in ACM		%	
% asbestos in sample		%	
Breakdown of Detailed Gravimetric Analysis (b)			
% Amphibole bundles in sample		Mass %	<0.001
% Chrysotile bundles in sample		Mass %	na
Breakdown of PCOM Analysis (c)			
% Amphibole fibres in sample		Mass %	na
% Chrysotile fibres in sample		Mass %	na
Breakdown of Potentially Respirable Fibre Analysis (d)			
Amphibole fibres		Fibres/g	na
Chrysotile fibres		Fibres/g	na

* Denotes test or material description outside of UKAS accreditation.
% asbestos in Asbestos Containing Materials (ACMs) is determined by
by reference to HSG 264.
Recommended sample size for quantification is approximately 1kg
# denotes deviating sample

Information in Support of the Analytical Results

Our Ref 21-25624
Client Ref 3822
Contract Wakefield Road

Containers Received & Deviating Samples

Lab No	Sample ID	Date Sampled	Containers Received	Holding time exceeded for tests	Inappropriate container for tests
1941822	TP02 2.00 SOIL	10/11/21	GJ 250ml, PT 1L		

Key: G-Glass P-Plastic J-Jar T-Tub

DETS cannot be held responsible for the integrity of samples received whereby the laboratory did not undertake the sampling. In this instance samples received may be deviating. Deviating Sample criteria are based on British and International standards and laboratory trials in conjunction with the UKAS note 'Guidance on Deviating Samples'. All samples received are listed above. However, those samples that have additional comments in relation to hold time, inappropriate containers etc are deviating due to the reasons stated. This means that the analysis is accredited where applicable, but results may be compromised due to sample deviations. If no sampled date (soils) or date+time (waters) has been supplied then samples are deviating. However, if you are able to supply a sampled date (and time for waters) this will prevent samples being reported as deviating where specific hold times are not exceeded and where the container supplied is suitable.

Disposal

From the issue date of this test certificate, samples will be held for the following times prior to disposal :-

Soils - 1 month, Liquids - 2 weeks, Asbestos (test portion) - 6 months

End of Report

Appendix J

Geotechnical Test Results

LABORATORY REPORT

4043

Contract Number: PSL21/8932

Report Date: 08 December 2021

Client's Reference: 3822

Client Name: Lithos Consulting
Parkhill
Walton Road
Wetherby
North Yorkshire
LS22 5DZ

For the attention of: Will Newton

Contract Title: Wakefield Road

Date Received: 12/11/2021
Date Commenced: 12/11/2021
Date Completed: 8/12/2021

Notes: Opinions and Interpretations are outside the UKAS Accreditation

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

Checked and Approved Signatories:

A Watkins (Director)

R Berriman (Quality Manager)

S Royle (Laboratory Manager)

L Knight (Assistant Laboratory Manager)

S Eyre (Senior Technician)

M Fennell (Senior Technician)

5 – 7 Hexthorpe Road, Hexthorpe,
Doncaster DN4 0AR
tel: +44 (0)844 815 6641
fax: +44 (0)844 815 6642
e-mail: rberriman@prosoils.co.uk
awatkins@prosoils.co.uk

SUMMARY OF LABORATORY SOIL DESCRIPTIONS

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Description of Sample
TP08	1	B	0.10		Dark brown slightly gravelly very sandy CLAY.
TP09	1	B	0.50		Brown very gravelly silty SAND.

UKAS TESTING
4043

Professional Soils Laboratory

Wakefield Road	Contract No:
	PSL21/8932
	Client Ref:
	3822

PARTICLE SIZE DISTRIBUTION TEST

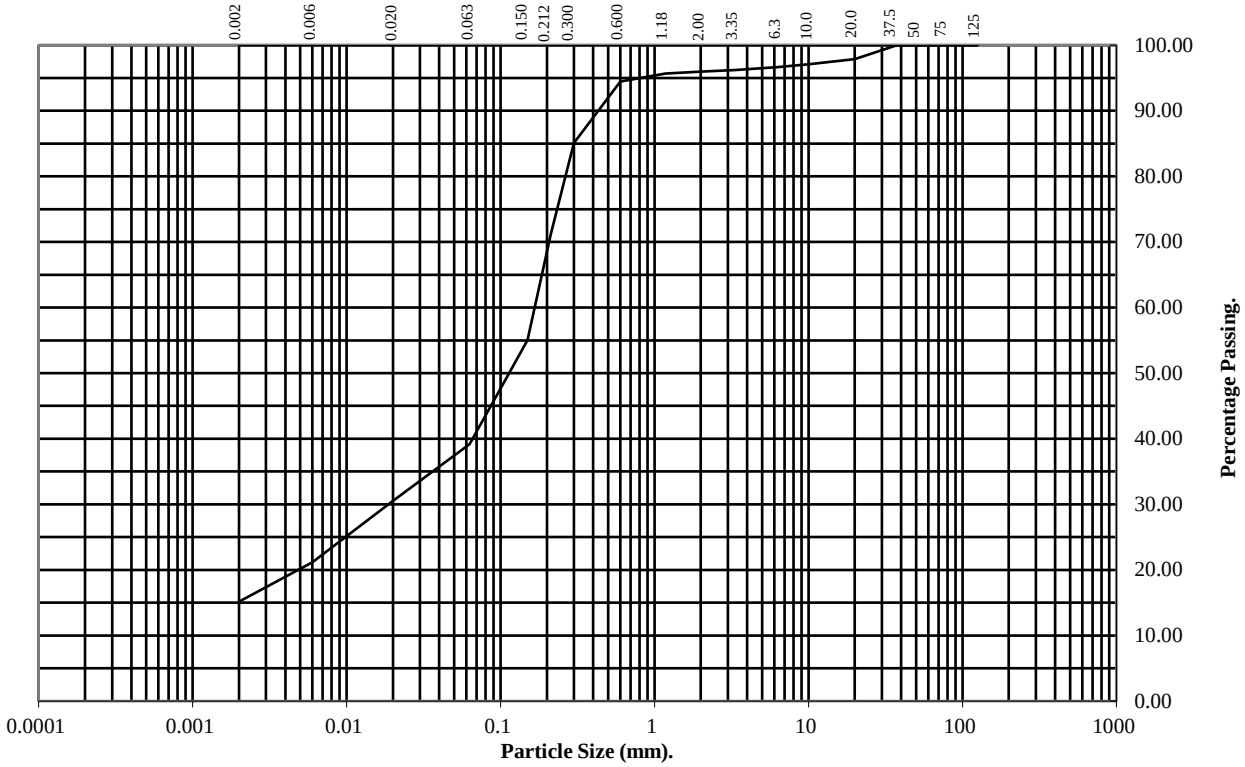
BS1377 : Part 2 : 1990

Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Hole Number: **Top Depth (m):** **0.10**

Sample Number: **B2** **Base Depth(m):**

Sample Type: **B**



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
50	100
37.5	100
20	98
10	97
6.3	97
3.35	96
2	96
1.18	96
0.6	94
0.3	85
0.212	71
0.15	55
0.063	39

Particle Diameter	Percentage Passing
0.02	31
0.006	21
0.002	15

Soil Fraction	Total Percentage
Cobbles	0
Gravel	4
Sand	57
Silt	24
Clay	15

Remarks:
See Summary of Soil Descriptions

PARTICLE SIZE DISTRIBUTION TEST

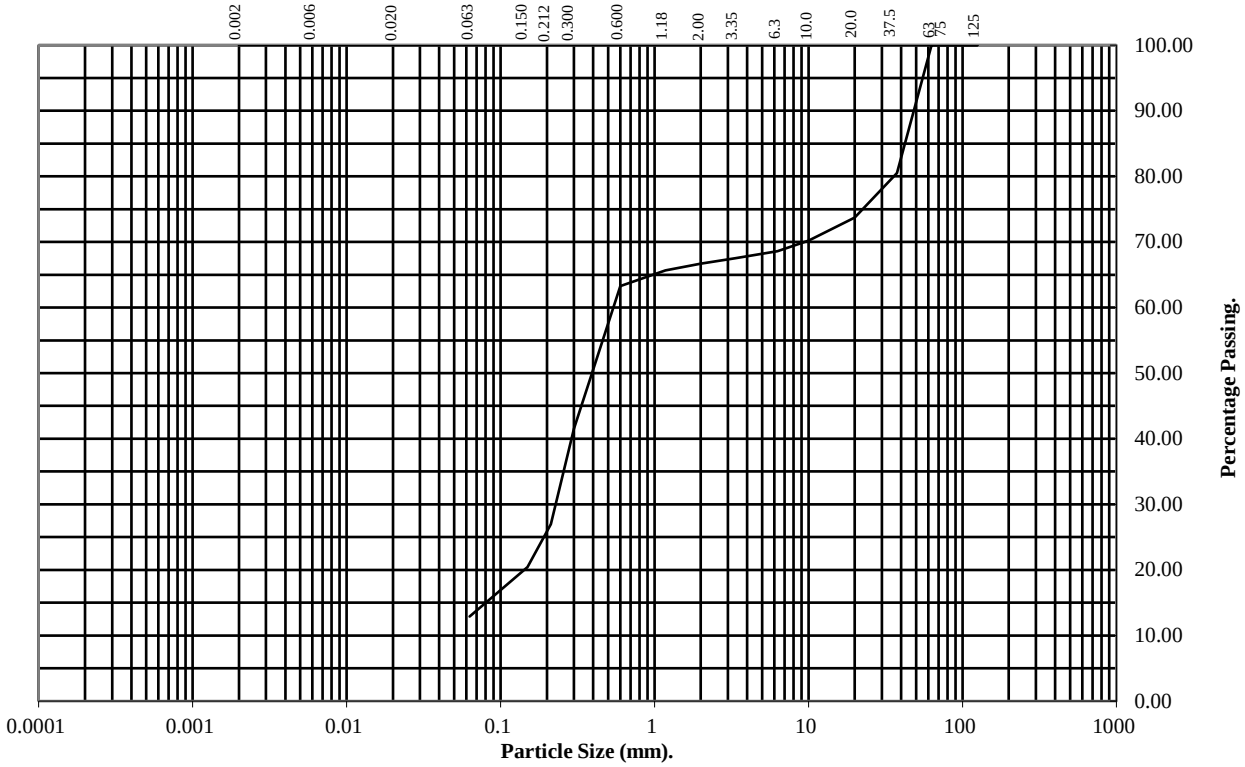
BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

Hole Number: **TP09** **Top Depth (m):** **0.50**

Sample Number: **1** **Base Depth(m):**

Sample Type: **B**



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	81
20	74
10	70
6.3	69
3.35	68
2	67
1.18	66
0.6	63
0.3	41
0.212	27
0.15	20
0.063	13

Soil Fraction	Total Percentage
Cobbles	0
Gravel	33
Sand	54
Silt/Clay	13

Remarks:

See Summary of Soil Descriptions