



Harworth Estates Investments Limited

Houghton Main

Preliminary Risk Assessment

322835-R01 (00)

RSK GENERAL NOTES

Report No.: 322835-R01 (00)

Title: Preliminary Risk Assessment: Houghton Main

Client: Harworth Estates Investments Limited

Date: June 2021

Office: RSK Environment Limited, Spring Lodge, 172 Chester Road, Helsby, Chester, WA6 0AR. Tel 01928 726006

Status: Rev 00

Author F Clayton **Technical reviewer** G McGuicken

Signature  Signature 

Project manager J Clayton **Quality reviewer** G McGuicken

Signature  Signature 

Revision control sheet				
Revision ref.	Date	Reason for revision	Amended by:	Approved by:
Rev 00	17 June 2021	First issue	n/a	see above

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1 INTRODUCTION

1.1 Commissioning

RSK Environment Limited (RSK) was commissioned by Harworth Estates Investments Limited (Harworth) to carry out a Preliminary Risk Assessment (PRA) of potentially contaminated land at their site at Houghton Main, Little Houghton, to the east of Barnsley. The project was carried out to an agreed brief as set out in RSK's proposal (Ref. 322835-TL01, dated 6 May 2021).

RSK's service constraints are shown in Appendix A.

The site is being considered for development for commercial use.

1.2 Objectives

The objective of the work is to produce a PRA report, providing information on the geological, hydrogeological and potential contamination status of the site, with data obtained from desk-based sources.

In addition, a Coal Mining Risk Assessment (CMRA) will be produced as a separate and standalone report, which will assess issues relating to the coal mining history of the site. Both this PRA, and the CMRA, will be used to develop a scheme of intrusive investigation to provide further details of ground conditions, where required.

1.3 Scope of works

The scope of this assessment has been developed in accordance with relevant British Standards and authoritative technical guidance as referenced through the report. The assessment of the contamination status of the site is in line with the technical approach presented in Land Contamination Risk Management (LCRM) (Environment Agency, 2021) and in general accordance with BS 10175: 2011 + A2 2017 (BSI, 2017). It is also compliant with relevant planning policy and guidance.

A brief summary of relevant legislation and policy relating to land contamination is given in Appendix B.

The scope of works for the PRA includes the following:

- A study of local geology and hydrogeology, including historical BGS boreholes.
- Coal Authority Consultants Mining report.
- The identification of potential geological hazards, including radon.
- A study of the land-use, development history and environmental data on and around the site and its surroundings from local authority correspondence, an Envirocheck report and archival Ordnance Survey mapping.
- The identification of aquifer vulnerability rating beneath the site and local water abstraction points from Environment Agency records.
- A site walk-over reconnaissance survey.

- The identification of potential targets at risk from possible contamination.
- Production of a preliminary conceptual site model (CSM).
- Recommendations for further work, including outline intrusive investigation recommendations.

A PRA report will be produced to include all the information detailed above.

1.4 Existing reports

The following reports detailing previous assessments of the site were made available for review:

- WYG Environmental, Geo-environmental Desk Study Report: Little Houghton, reference E35220-2, November 2008.
- South Yorkshire Mining Advisory Service (SYMAS), Mineral Report, Houghton Main Colliery Site, Little Houghton Proposed Redevelopment, reference IJ/M461/6, March 2008 (presented as an appendix to the WYG report).

It should be noted that the site covered by the WYG report and associated SYMAS report was slightly smaller than the site area covered by the current assessment. Pertinent information from these reports have been summarised in Section 3.

1.5 Limitations

This report is subject to the RSK service constraints given in Appendix A and limitations that may be described through this document.

2 SITE DETAILS

2.1 Site location

Site location details are presented in Table 1 and a site location plan is provided as Figure 1.

Table 1 Site location details

Site name	Houghton Main
Full site address and postcode	Land in the area of the former Houghton Main Colliery, Park Spring Road, Little Houghton, nearest postcode S72 0HR
National Grid reference (centre of site)	442070, 405916

2.2 Site description

The site boundary and current site layout are shown on Figure 2. The site covers an area of approximately 5.9 hectares and is located to the south of the recently constructed ASOS warehouse building, and east of the A6195 near Little Houghton.

The site is currently mainly covered by vegetation and is overgrown in most parts, particularly along the line of drainage features. There is evidence of fly-tipping and former buildings, with some waterlogged areas noted.

2.3 Surrounding land uses

The site is located on the edge of Little Houghton, approximately 13 miles to the east of Barnsley, within a mixed residential, industrial and amenity setting. Immediate surrounding land uses are described in Table 2.

Table 2 Surrounding land uses

North	ASOS facility (large warehouse with associated car parking)
East	Electricity distribution site to east of southern section. Agricultural land with some wind turbines. Sandhill Golf Club to south east
South	Middlecliffe Lane with some residential properties, woodland
West	A6195, River Dearne, agricultural land

2.4 Development plans

The proposed layout of the site, at the time of preparing this report, is shown in Appendix B.

The extent and nature of the new development layout is illustrative at this stage, and may be subject to amendments prior to submission as part of a new planning approval.

3 DESK-BASED ASSESSMENT

The desktop study was designed generally to meet the objectives of a preliminary (phase 1) investigation, as defined by BS 10175:2011 (BSI, 2017) and this assessment relates to LCRM Stage 1, Tier 1 preliminary risk assessment. The 'vicinity' of the site for the purposes of this report is defined as locations situated within an approximate 250m radius of the site, although certain sources and/ or sensitive targets further than 250m may also have been considered.

The study aims principally to identify and assess the potential risks and liabilities associated with contamination of the ground, on and in the vicinity of the site. While this includes consideration of current operations and housekeeping on the site, the report does not constitute a comprehensive environmental audit of the site, as covered under ISO 14001.

3.1 Site history

3.1.1 Historical development record

The development history of the site and surrounding area based upon assessment of historical plans and records is detailed in Table 3. The Ordnance Survey historical maps reviewed are shown within the environmental database report in Appendix D. Further details have been obtained from mapping of coal seam workings taken from the SYMAS report (2008).

Table 3 Summary of historical development

Date	Historical Land Use (on-site)
1854	The site is occupied by fields, with a lane crossing the centre roughly from north to south east.
1893	Houghton Main Colliery present with rail lines, buildings, chimneys, tanks, etc in northern and central areas. Row of cottages present on-site, and other buildings around southern end. Deep mining included working of eight coal seams from the Meltonfield Coal Seam at 316m to the Silkstone Coal Seam at 790m.
1906	Sewage works including sludge beds and filter beds in centre of site, as well as the colliery. Some evidence of excavation works in south area.
1932	Institute building present in south east of site, with recreation site partly within boundary south east of that.
1962	Pond marked in north east corner of site.
1975	Mine adit discovered within the site boundary, indicating the likelihood of some working of the Shafton coal seam. Although it is not recorded, this is assumed to have been removed during opencast workings (see below).
1983	Reduction in colliery infrastructure present across site (particularly rail lines).

1997	Opencast working commenced on-site, in the Shafton Coal Seam. Prior to this date, all colliery buildings and infrastructure had been removed. A6195 road passes directly through site (from south to north east).
2000	Opencast works were completed by 2000 and excavations had been backfilled (with compaction of backfill during restoration to form a development platform, according to the WYG report).
2021	Route of A6195 moved to south west, so no longer passing through site.
Date	Historical Land Use (off-site)
1854	Midland Railway immediately adjacent to site to west, with River Dearne and associated flood plain west of that.
1893	Houghton Main Colliery extends off-site to the north. Clay pit to north of colliery. Manor House off-site to south east.
1906	Dearne Valley Colliery off-site to the south.
1922/23	Houghton Main Colliery shafts constructed at this time (just off-site to north), up to 730m deep (to reach Thorncliffe Coal Seam).
1932	Further extension of colliery to north of site. Spoil heaps off-site to north east, include aerial cables.
1955	Spoil heaps extensive to north east.
1967	Spoil heaps still extensive off-site to north east.
1983	Route of River Dearne straightened on west of main railway line.
1993	Three mineshafts off-site to north thought to have been filled and capped shortly after 1993 to British Coal specifications.
2000	Railway to west of site disused. Quarry marked to north of site where colliery was previously located. During opencast works (both on- and off-site, the three shafts north of the site were uncovered, caps were removed and new caps were installed at the base of the opencast void (approximately 11m deep), before backfilling operations were completed.
2002	Post-backfill monitoring indicated that groundwater levels stabilised by 2002, after a period of rising following the cessation of pumping associated with the mining activities.
2007	A coal mine methane extraction plant was constructed north west of the site to generate electricity. This is connected to the substation to the south east of the site via an underground cable passing beneath the site along the south west and south east boundaries.
2021	A6195 road now present along former route of disused railway. Large warehouse facility (ASOS) present off-site to the north.
Information sources: Historical OS maps, Aerial photography, Coal mining abandonment plan, coal workings drawings, SYMAS report, WYG desk-based assessment report	

The key historical events affecting the site are the deep mining history, and the opencast workings that were subsequently backfilled. Any contamination resulting from deep mining is expected to have been removed during opencast works.

3.1.2 Unexploded ordnance

A review of publicly available unexploded ordnance (UXO) risk maps indicates that the site is located in an area with low potential for risks relating to unexploded ordnance to be present (Zetica, 2021).

3.2 Information from environmental database report

Relevant environmental permits and incidents detailed within the environmental database report (see Appendix D) are summarised below in Table 4.

Table 4 Summary of environmental permits, landfills and incidents

Data type	Entries on-site	Entries <250m from site	Entries >250m from site of relevance	Details
Agency and hydrological				
Environmental permits	0	0	0	
Enforcement and prohibition notices	0	0	0	
Pollution incidents to controlled waters	0	2	0	Both incidents over 20 years ago, minor incidents
Discharge consents	0	0	0	None within 500m
Registered radioactive substances	0	0	0	
Landfill and waste				
Active landfills	0	0	0	
Historic / closed landfills	0	0	1	Historical site 725m to north of site (no other details)
Other waste management licences	0	0	0	
Potentially in-filled land (pit, quarry, pond, marsh, river, stream, dock etc)	1	1	1	Opencast coal areas, backfilled with compacted material
Hazardous substances/ industrial land uses				
Control of Major Accident Hazards (COMAH) sites	0	0	0	
Contaminated land Part 2A register entries and notices	0	0	0	

Data type	Entries on-site	Entries <250m from site	Entries >250m from site of relevance	Details
Contemporary trade directory entries	0	0	1	Sound equipment manufacturer
Fuel station entries	0	0	0	

3.2.1 Site services

Buried utility services and their backfill can provide preferential pathways for gas, vapour or groundwater to migrate along to another part of the site or to a receptor. They can also represent significant constraints to development.

Obtaining a full set of service plans was outside the scope of this report, however, some services information has been made available.

A sewer crosses the site from south east to centre west, assumed to be laid through the opencast backfill materials.

Services identified on-site during the walkover are detailed in Section 4.

3.3 Summary of previous assessments

A summary of pertinent information from the assessment undertaken by WYG in 2008 is provided in this section.

The WYG report includes with details about site geology, etc, which correlates to the later sections of the present report. Information is provided relating to the site surface mining and reclamation works, which involved the opencast extraction of coal from the Shafton coal seam, followed by supervised placement of backfill and restoration to allow later development to take place on the site.

The backfill works were carried out by Babbie Group, on behalf of British Coal, and the work was reported as Houghton Main Opencast Site: Compaction Certificate Report (Draft), dated September 2004. The Babbie report is referenced in the WYG report, but was not provided as an appendix, and has not been reviewed directly. Backfill works incorporated field and laboratory testing to ensure the required parameters were being met. Post-backfill, monitoring of groundwater levels and ground settlement were undertaken. Groundwater pumping is indicated to have ceased in February 2000, and levels were noted to rise until January 2002, at which point they stabilised. Settlement monitoring showed near surface settlements of 20mm to 50mm as groundwater levels rose. Plate load tests were undertaken, and showed that for a load of 110kPa, settlement varied from 4.5mm (900mm diameter plate) to 5.0mm (610mm diameter plate).

The report states that opencast works carried out between 1997 and 2000 involved demolition of all historical mining structures, and capping of mine entries (these are assumed to be the shafts located off-site to the north). Specific mention of the two adits is not made, but it is assumed that these were removed during opencast excavation works.

The WYG report indicated that the Babbie compaction certificate report provided an assessment of ground settlement affecting the backfill material as a result of creep settlement, inundation settlement and settlement due to imposed loads. Calculations suggested that self-weight settlement (creep) of 150mm would be expected within the first 10 years after placement of backfill, with a further 150mm over the ensuing 90 years. Inundation settlement occurs as a result of changes to the backfill material as groundwater levels adjust (in this case after pumping of mine waters ceased and standing levels within the backfill came into equilibrium). Babbie estimated that some inundation settlement had occurred in saturated fill, but that further settlement in the range of 20mm to 45mm could still be expected. In addition to creep and inundation settlement, the presence of loads caused by building structures would be expected to result in further settlement. Based on field testing, Babbie estimated settlement of less than 20mm for structures with shallow spread foundations and loadings of around 100kPa. This was calculated when the site was proposed for residential end-use. It was noted that differential settlement should be expected due to variable conditions across the site, because of the presence of high walls, and distribution of backfill materials and original natural soils. The WYG report recommended that buildings should avoid crossing the areas of the main highwalls.

Comments relating to ground conditions from the WYG report have been incorporated into the relevant sections of this report.

3.4 Site geology

3.4.1 Anticipated geological sequence

Geological records for the area (British Geological Survey Onshore GeoIndex, accessed May 2021) and available historical borehole logs indicate the geology of the site to be characterised by the succession recorded in Table 5. There are 15 publicly available BGS boreholes located on or within 250m of the site, which are presented in Appendix E.

Table 5 Site geology

Strata	Description	Estimated thickness	Hydrogeology
Made ground	Made ground may be present outside of the opencast areas, associated with historical buildings or colliery infrastructure previously on-site	Not known, but expected to be relatively shallow	N/A
Made ground (opencast backfill)	Backfill placed after completion of opencast mining, generally a mixture of reworked mudstones, siltstones and sandstones	Between 10m and 16m (see Section 3.5.1 for more details)	N/A
Alluvium (superficial deposit)	Most of the site has no superficial deposits. Alluvium comprising clay, silt, sand and gravel is present only close to the River Dearne, in the north western site corner	Not known	Secondary A aquifer
Pennine Middle Coal Measures (bedrock)	Present across the whole site, comprising mudstone, siltstone and sandstone with coal seams	Up to 650m. Shafton coal seam likely to be shallow on the eastern side of site (seam thickness around 1.4m)	Secondary A aquifer
Information sources: BGS Geoindex, BGS borehole logs, WYG report			

Linear features are shown on the GeoIndex mapping in the form of coal seams sub-cropping across the site approximately from north west to south east, and fault lines present just off-site to the south, and to the west of the River Dearne.

As the site is known to have been used for open cast coal extraction, there is infill material across the majority of the site, which was placed under supervision following a Department of Transport specification for road and bridge works standards, 1976 (WYG, 2008).

Borehole records available for the southern section of the site include partial records for two deep boreholes, with no details of upper layers of strata (references SE40NW26 and SE40NW27). Boreholes clustered in the north eastern section of the site show a layer of made ground to a depth ranging between 1.5m to 6.3m, typically comprising ash, burnt mudstone, brick fragments, gravel and clay nearer the surface, with reworked sandstone, mudstone, clay and occasional coal at greater depth. Natural soils were present as sandstone, clay and mudstone. A coal seam was encountered at depths varying between 11m and 14m (to the top of the seam), and thicknesses of 1.3m to 2.35m.

3.4.2 Radon

The environmental database report indicates that parts of the site are located within an intermediate probability radon area, where 1% to 3% of homes are estimated to be at or above the radon action level, and parts of the site are low probability (less than 1% of homes are above the radon action level).

The risk of significant ingress of radon into structures on-site is considered low and protection measures are not necessary in the construction of non-domestic buildings.

Although the radon data used in production of the 'UKradon' indicative atlas comes from measurements in homes, the maps indicate the likely extent of the local radon hazard in all buildings.

3.5 Mining and quarrying

Evidence has been sought to identify any mining, quarrying, landfilling and land reclamation operations, past and present, which have taken place within 500m of the site.

3.5.1 Coal mining area

The site is located over Coal Measures bedrock and is known to have been historically affected by both underground and surface coal mining activities. The assessment of mining legacy issues should be carried out in accordance with the guidance provided by the Coal Authority, who adopt a risk-based approach for the advice that they offer on proposed development sites. The Coal Authority are a statutory consultee to Local Planning Authorities in respect of building development within the defined coal mining areas of England, Wales and Scotland where a planning application is required.

The site lies within the Coal Authority Consultation Area and is within a Development High Risk Area. Based on the location and mining history of this site, a coal mining risk assessment (CMRA) is required to form part of the planning application. This has been prepared as a separate document (RSK report reference 322835-R02(00)). A short summary of key issues is provided in this preliminary risk assessment, but the CMRA should be consulted for full details.

A Coal Authority Consultants Coal Mining report has been obtained for the site, and although information is presented here, the full report is reproduced as an appendix in the separate CMRA report.

Table 6 Summary of key coal mining information

Item	Applicable to site?	Comment
Development High Risk Area on-site	Yes	-

Item	Applicable to site?	Comment
Coal mine entries	Yes	One mine adit was found to be present within the site boundary, on the western side of the site, but this is understood to have been removed during opencast works. Two adits are shown in the Coal Authority report, one assumed to be that mentioned above, and one located further west, possibly just off-site along the A6195. The other nearest mine shafts are all off-site to the north, and treatment details are provided in the Coal Authority report.
Past shallow workings (recorded)	Yes	An adit found in 1975 (prior to surface mining) suggests that shallow workings may have been present within the Shafton coal seam.
Probable shallow workings	Yes	The Coal Authority report indicates that shallow workings may be present in the area. However, the WYG report indicates that no evidence of this was encountered during opencast works.
Coal seam outcrops	Yes	An outcrop from one coal seam is shown to cross the site (Shafton coal seam, worked by opencast operations).
Surface mining (opencast)	Yes	The site was part of a wider area of opencast workings.
Other	Mine gas conversion	There is an electricity generation station converting mine gas into electricity located to the north west of the site.

3.5.2 Areas of other mining (rock or mineral)

There are no other types of mineral extraction known to have occurred in the area of the site other than a clay pit off site to the north indicated on the historical Ordnance Survey plan from 1893.

As noted above, a CMRA has also been completed for this site, and should be referred to for further information relating to coal mining issues (RSK report reference 322835-R02, dated June 2021).

3.6 Hydrogeology

A summary of the hydrogeological setting of the site, with respect to the anticipated geological sequence set out in Section 3.4 is presented below in Table 7.

Table 7 Hydrogeological setting

Condition	Description
Aquifer characteristics	The site is underlain by secondary A aquifers relating to both the superficial geology and the bedrock geology. The site is relatively close to the River Dearne (which is located approximately 80m to the west of the site), so it is expected that groundwater would flow in a south westerly direction towards the river.
Depth to groundwater and flow	Borehole data from the BGS (see Appendix E) indicates that groundwater was not encountered in a series of boreholes completed in 1986. These ranged in depth from 4.65m to 15.5m. If shallow groundwater is present in the site area it would be anticipated to flow in a south westerly direction, towards the River Dearne. It should be noted that the presence of excavations infilled after opencast mining operations could have affected the natural groundwater movements in the area. It is possible that shallow groundwater may be present in made ground/infilled deposits present on-site.
Rising groundwater levels	Although the site is located in a former coal mining area, it is not expected to be associated with any further rebounding groundwater levels. Groundwater monitoring indicated that levels post-mining had stabilised by 2002.
Groundwater recharge/attenuation	Most of the site is currently unsurfaced and will therefore drain to ground.
Historical implications for hydrogeology	Placement of backfill will have impacted the hydrogeological nature of the site, and conditions will not necessarily be consistent.
Licensed groundwater abstractions	There are no current licensed groundwater abstractions within a 1km radius of the site.
Source protection zones	Information available from the MAGIC website indicates that the site does not lie within a currently designated groundwater Source Protection Zone (SPZ).

3.7 Hydrology

Information relating to the hydrology within the site area is summarised in Table 8.

Table 8 Summary of hydrology in site area

Condition	Description
Surface watercourses/features	A watercourse is present running along the northern site boundary in a ditch approximately 4m deep. This runs from north east to south west, and enters a culvert part way down the western site boundary to cross beneath the A6195 road. The culvert entrance is just within the site boundary. A narrower ditch (approximately 1m deep) crosses the site from the south east to join the larger watercourse at the culvert.

Condition	Description
Surface water abstractions	There are no surface water abstractions identified by the environmental database within a 1 km radius of the site.
Site drainage	Surface drainage from the site appears to be into the ditch and watercourse detailed above, which flows into the River Dearne, off-site to the west.
Preliminary flood risk assessment	A flood zone associated with the River Dearne is present off-site to the west, but the A6195 road forms the boundary of this flood area. The site is categorised as at low risk of flooding from rivers. However, there is the potential for flooding from surface water in the area where the main watercourse enters the culvert, as well as in the north eastern corner of the site.

3.8 Sensitive land uses

There are no areas of designated sensitive land use within 500m of the site.

4 SITE RECONNAISSANCE FINDINGS

A site reconnaissance survey was completed on 26 May 2021 by RSK. The characteristics of the site observed during the walkover and from current Ordnance Survey maps are summarised in Table 9.

A site plan is provided in Figure 2 with photographic records included in Appendix F detailing the main features identified below.

Whilst the walkover summary includes consideration of current operations and housekeeping on the site as potential sources of contamination, it does not constitute a comprehensive environmental audit of the site, as covered under ISO 14001.

Table 9 Site reconnaissance findings

Feature	Description
Physical characteristics	
Access constraints	Dense vegetation covers the site surface, except for the central part of site - limited access at the edges of site, particularly alongside the drain.
Site topography	The site surface is uneven and generally slopes downwards from a high point of approximately 36m AOD in the south east to a low point of approximately 32m AOD in the north west.
Surface cover	The site is unsurfaced ground covered by vegetation.
Site drainage	Surface water run-off from the site appears to collect in the on-site drains. Some water has collected in track ruts. The north western part of site was noted to be waterlogged.
Surface water	An open drainage channel is present in the northern part of site, close to the perimeter.
Trees and hedges	Vegetation present on-site comprises grass, scrub vegetation and trees.
Invasive species	Based upon the walkover survey obvious evidence of Japanese Knotweed or other invasive species has not been identified on-site. However, it should be noted that a detailed survey of the possible presence or absence of invasive species is outside of the scope of investigation and consideration should be given to commissioning a specialist survey, as necessary.
Existing buildings on-site	No buildings are present on site. Remnants of former buildings noted in the eastern part of site (brick walls). Some piles of concrete and brick also noted.
Retaining walls and adjacent buildings on or close to site boundary	No such structures were identified on or close to the site boundary.
Basements on-site	No evidence of existing or infilled basements was observed.

Feature	Description
Made ground, earthworks and quarrying	Ground conditions at the surface appear to be made ground (colliery spoil/ opencast backfill) – slightly sandy gravelly clay; gravel is mudstone and sandstone.
Potentially unstable slopes on or close to site	None observed.
Buried and overhead services present	Manhole cover observed in western part of site and two manhole covers observed in road near site entrance. Overhead line crosses southernmost part of site.
Environmental characteristics	
Underground/ above ground storage tanks and pipework	None observed.
Potentially hazardous materials storage and use	None observed.
Asbestos-containing materials	A pile of suspected asbestos containing cement sheet roofing was observed in the north easternmost part of site.
Waste storage	None observed.
Fly-tipping	Some fly-tipping and general littering observed.
Electricity sub-stations/ transformers	Electricity substation adjacent south east of site.
Evidence of possible land contamination on-site	None observed.
Potential off-site sources of ground contamination	None observed.

Key issues noted are that there may be access restrictions for any site investigation works due to the overgrown vegetation, and there appears to be some potentially asbestos-containing material locally present on the site surface.

5 PRELIMINARY GEOTECHNICAL CONSTRAINTS

5.1 Design class

BS EN 1997-1 defines three different Geotechnical Categories that structures may fall into, which are summarised as follows:

- Category 1: Small and relatively simple structures for which it is possible to ensure that the fundamental requirements will be satisfied on the basis of experience and qualitative geotechnical investigations; with negligible risk.
- Category 2: Conventional types of structure and foundation with no exceptional risk or difficult ground or loading conditions.
- Category 3: Structures or part of structures, which fall outside limits of Geotechnical Categories 1 and 2. Examples include very large or unusual structures; structures involving abnormal risks, or unusual or exceptionally difficult ground or loading conditions; structures in highly seismic areas; structures in areas of probable site instability or persistent ground movements that require separate investigation or special measures.

Based on the information provided above on the proposed development and in view of the anticipated ground conditions, a Geotechnical Category of 3 has been assumed for the purposes of designing the geotechnical investigation. This should be reviewed at all stages of the investigation and revised where necessary.

5.2 Preliminary geotechnical hazards assessment

A summary of commonly occurring geotechnical hazards associated with the anticipated geology outlined in Section 3.4 above is given in Table 10 together with an assessment of whether the site may be affected by each of the stated hazards.

Table 10 Summary of preliminary geotechnical risks that may affect site

Hazard category	Hazard status based on desk study findings and proposed development		Engineering considerations if hazard affects site
	Could be present and/or affect site	Unlikely to be present and/or affect site	
Sudden lateral changes in ground conditions	☒	☐	Likely to affect ground engineering and foundation design and construction
Shrinkable clay soils	☐	☒	Design to accommodate shrinkable clays and potential

Hazard category	Hazard status based on desk study findings and proposed development		Engineering considerations if hazard affects site
	Could be present and/or affect site	Unlikely to be present and/or affect site	
			heave (NHBC Standards Chapter 4 or similar)
Highly compressible and low bearing capacity soils, (including peat and soft clay)	☒	☐	Likely to affect ground engineering and foundation design and construction
Silt-rich soils susceptible to rapid loss of strength in wet conditions	☐	☒	Likely to affect ground engineering and foundation design and construction
Running sand at and below water table	☐	☒	Likely to affect ground engineering and foundation design and construction
Karstic dissolution features (including 'swallow holes' in Chalk terrain)	☐	☒	May affect ground engineering and foundation design and construction
Evaporite dissolution features and/or subsidence	☐	☒	May affect ground engineering and foundation design and construction
Ground subject to or at risk from landslides	☐	☒	Likely to require special stabilisation measures
Ground subject to peri-glacial valley cambering with gulls possibly present	☐	☒	Likely to affect ground engineering and foundation design and construction
Ground subject to or at risk from coastal or river erosion	☐	☒	Likely to require special protection/stabilisation measures
High groundwater table (including waterlogged ground)	☒	☐	May affect temporary and permanent works
Rising groundwater table due to diminishing abstraction in urban area	☐	☒	May affect deep foundations, basements and tunnels
Geological faults, fissures and break lines	☒	☐	May affect ground engineering and foundation design and construction
Underground mining including shafts and adits (e.g. coal, mineral)	☒	☐	Likely to require further assessment including potentially special stabilisation measures

Hazard category	Hazard status based on desk study findings and proposed development		Engineering considerations if hazard affects site
	Could be present and/or affect site	Unlikely to be present and/or affect site	
Effects of extreme temperature (e.g. cold stores or brick kilns/furnaces)	☐	☒	Likely to affect ground engineering and foundation design and construction
Existing sub-structures (e.g. tunnels, foundations, basements, and adjacent sub-structures)	☐	☒	Likely to affect ground engineering and foundation design and construction
Filled and made ground (including embankments, infilled ponds and quarries)	☒	☐	Likely to affect ground engineering and foundation design and construction
Adverse ground chemistry (including expansive slags and weathering of sulphides to sulphates)	☐	☒	May affect ground engineering and foundation design and construction
Site topography	☐	☒	May affect ground engineering and foundation design and construction

6 INITIAL CONCEPTUAL SITE MODEL

In the UK land contamination is assessed using a risk-based approach taking account of the magnitude (severity of the hazard) and likelihood (probability) of occurrence. A 'receptor' is something that could be adversely affected by contamination (e.g. people, an ecological system, property or a water body). A 'pathway' is a route or means by which a receptor is or could be exposed to or affected by a contaminant. A 'contaminant source' is a hazard but it can only pose a risk to a receptor where a pathway is present. The relationship between sources, pathways and receptors are referred to as a conceptual site model (CSM). A risk can only be realised where a contaminant source, pathway and receptor are all in place, referred to as a 'pollutant linkage'.

In line with LCRM (Environment Agency, 2021) and BS 10175: 2011 + A2 2017 (BSI, 2017), RSK has used information in the preceding sections to identify hazards (sources of contaminants), receptors that may be impacted and plausible linking pathways. Where all three are present this is termed a potentially complete contaminant linkage and a qualitative risk estimation is required.

6.1 Potential soil, soil vapour and groundwater linkages

6.1.1 Potential sources of contamination

Potential sources of soil and groundwater contamination identified from current activities and the history of the site and surrounding area are presented in Table 11. Ground gas sources are addressed in Section 6.2.

Table 11 Potential sources of soil and groundwater contamination

Potential sources	Contaminants of concern
On-site	
S1: Made ground (opencast excavation backfill material)	Material reported to comprise mudstone, siltstone and sandstone, but there is the potential for some unreported material, potentially including brick, ash and clinker and containing toxic and phytotoxic metals, inorganics, polycyclic aromatic hydrocarbons (PAHs), asbestos.
S2: Colliery contamination	Majority of colliery infrastructure removed during opencast works, but there may be some remnants of contamination (possibly including PAHs, toxic and phytotoxic metals, impacted mine waters).
S3: Area of former cottages	Possible demolition materials, including asbestos-containing materials, brick, ash.
S4: Sewage works including sludge beds and filter beds	Opencast works will have removed majority of possible contamination associated with sewage works (remaining pollutants could include metals, metalloids, inorganic compounds, acids or alkalis).
S5: Former route of A6195 passed through site	Base for road may have incorporated made ground fill, possibly including bricks, ash, asbestos.

Potential sources	Contaminants of concern
Off-site	
S6: Former railway line running along western site boundary (now the A6195 road)	Petroleum hydrocarbons, toxic and phytotoxic metals, inorganics, PAHs, asbestos, herbicides.
S7: Collieries off-site to north and south, with spoil heaps	PAHs, toxic and phytotoxic metals, impacted mine waters, mine gases.
S8: Electricity substation	PAHs, PCBs.
Infilled former clay pit (to north of site)	Unknown fill material, and location off-site and presence of underlying clay material (of low permeability) means that this is not considered to be a viable source.
Note: source reference numbers are assigned where sources are considered significant. If no reference number is given, the source is not considered likely to form a complete pollutant pathway	

6.1.2 Sensitive receptors and linking exposure/ migration pathways

Sensitive receptors identified at or in the vicinity of the site that could be affected by the potential sources identified above comprise the following, with potential linking pathways shown in brackets for each item:

- R1: future site users – commercial/ industrial workers [oral, dermal and inhalation exposure with impacted soil, soil vapour and dust, possible explosion risk from gases]
- R2: current adjacent site users – residential and commercial, [migration of contamination via dust/fibre deposition, vapour or groundwater migration combined with inhalation]
- R3: proposed buildings and services [direct contact with contaminated soils or groundwater and chemical attack, possible explosion risk from gases]
- R4: existing/ future vegetation [direct contact with contaminated soils or groundwater and root uptake leading to phytotoxicity]
- R5: groundwater in secondary A aquifer within superficial deposits [leaching from soils/ percolation to aquifer/ lateral migration of dissolved phase]
- R6: groundwater in secondary A aquifer within bedrock deposits [percolation through permeable strata to aquifer/ lateral migration of dissolved phase]
- R7: surface drainage ditches within site and “inland river” watercourse (along northern site boundary), leading to River Dearne off-site to the west [lateral migration of dissolved phase/ LNAPL / site run-off/ drainage].

Please note that construction workers and future maintenance workers have not been identified in the CSM as receptors because potential risks to them are considered to be managed through health and safety procedures according to the CDM Regulations.

6.2 Potential ground gas linkages

6.2.1 Ground gas generation potential

Potential ground gas sources identified for the site and surrounding are shown in Table 12.

Table 12 Potential ground gas sources

Potential sources	Indicative ground gas generation potential (CIEH, 2008)	Additional information
On-site		
Made ground with low degradable organic content (e.g. up to 5% organic material and no easily degradable waste)	Very low	Opencast backfill not taken forward for further assessment as not considered a viable pollutant linkage
Sewage sludge	Moderate	Not expected to remain on-site post-opencast workings, so not taken forward as a viable pollutant linkage
S9: Mine workings more than 50 years since last worked	Moderate	Most of the deep mine workings were last worked over 50 years ago. Some of these are connected to the coal mine methane extraction scheme on land to north west, but details of which shafts/adits are connected are not known
S9: Mine workings less than 50 years since last worked	High	Two of the coal seams mined at depth were worked within the last 50 years (Silkstone and Middleton Coal Seams)
Off-site		
Infilled pond and clay pit shown on historical plans	Very low	Not sufficiently close to site to be of concern
Note: - Source reference numbers are assigned where sources are considered significant. If no reference number is given, the source is not considered likely to form a complete pollutant pathway. - Although a number of potential sources (above) are not considered viable this is based on this desk-based review only. In order to obtain planning permission for any development a further assessment of the site-wide ground gas regime, including these sources, will be required and ground gas is identified as a potentially complete pollutant linkage in Section 6.3 below.		