



**DATE REVIEW AND GAP
ANALYSIS**

**Former Monckton Coking Works,
Lund Hill Lane,
Royston
Barnsley
South Yorkshire
S71 4BD**

**For
Monckton Developments Limited**

October 2019

19/B0010.1.2

Geo² Remediation Limited

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Table of Contents

1.0.	INTRODUCTION AND AIMS.....	4
1.1	Introduction.....	4
1.2	Aims	4
1.3	Historic Reports	5
2.0	SITE SETTING	6
2.1	Site Location.....	6
2.2	Site Areas.....	6
2.3	Site Levels.....	7
2.4	Site Setting	7
2.5	Sensitive Receptors.....	7
3.0	SITE OPERATIONS	8
3.1	Stockyard and Former Colliery.....	8
3.2	Production and By-Products Area.....	8
3.2.1	Coke Production.....	8
3.2.2	By Product Processing.....	9
3.3	Southern Site Section	9
3.4	Western Land Parcel	9
4.0	SITE GEOLOGY	10
4.1	Reported Geology.....	10
4.2	Hardstanding	10
4.3	Made Ground.....	10
4.4	Superficial Deposits	11
5.0	HYDROGEOLOGY.....	12



5.1	Aquifer Vulnerability.....	12
5.2	Groundwater Monitoring Data.....	12
6.0	HYDROLOGY	13
7.0	SITE HISTORY.....	14
7.1	Historical Map Review	14
7.2	Historical Walkover Notes.....	15
7.2.1	Walkover: Production Area.....	15
7.2.2	Walkover: Ammonia Production Area.....	16
7.2.3	Walkover: CHP Plant	16
7.2.4	Walkover: Workshops	16
7.2.5	Walkover: Stockyard	16
7.2.6	Walkover: Substations.....	16
7.2.7	Walkover: Tanks	17
8.0	SUMMARY OF INVESTIGATION WORKS TO DATE.....	18
8.1	Investigation: Stockyard.....	19
8.1.1	Analysis of Breeze	19
8.1.2	Stockyard: Analysis of Made Ground	19
8.1.3	Investigation of the Clay Pit.....	19
8.1.4	Investigation of the Railway Tunnel.....	20
8.1.5	Stockyard: Assessment of Groundwater	20
8.2	Investigation: Production and By-Products	20
8.2.1	Production and By-Products: Made Ground Analysis	21
8.2.2	Production and By-Products: Groundwater Analysis	21
8.3	Investigation: Southern Area.....	22
9.0	CALORIFIC VALUE	23
10.0	OBSTRUCTIONS.....	24
11.0	GROUND GAS.....	25
12.0	ASBESTOS.....	26
12.1	Asbestos Inspections	26
12.2	Asbestos Sampling of Soils	26
13.0	COAL RISK.....	27
13.1	Coal Authority Search	27
13.2	Mine Shafts	27
13.3	Subcropping Coal Seams.....	28
14.0	INVASIVE SPECIES	29
15.0	RADON	30
16.0	SILICATE BRICKS.....	31

17.0	BURIED CONCRETE	32
18.0	FLOODING.....	33
19.0	CONCEPTUAL SITE MODEL AND GAP ANALYSIS	34
19.1	Sources.....	34
19.1.1	Combustible Shallow Soils and Asbestos.....	34
19.1.2	PAH, Metal and Asbestos Contamination within Made Ground	34
19.1.3	Hydrocarbon and Tar / Oil Contamination	35
19.1.4	Silica Bricks.....	35
19.1.5	Ground Gases.....	36
19.2	Pathways	36
19.2.1	Direct Contact, Inhalation and Ingestion.....	36
19.2.2	Groundwater Migration.....	36
19.2.3	Accumulation of Vapours or Gases	36
19.3	Receptors.....	36
19.3.1	Future Residential Site Users.....	36
19.3.2	Offsite Land Users	37
19.3.3	Controlled Waters	37
19.3.4	Sensitive Land Uses	37
19.3.5	Structures Onsite	37
19.4	Contaminant Linkages.....	38
20.0	OUTLINE DEVELOPMENT CONSIDERATIONS	39
20.1	Development Constraints	39
20.2	Outline Remediation Strategy.....	40
21.0	LIMITATIONS.....	42
22.0	REFERENCES	43

Appendices

Appendix A Figures

- Figure 1 - Site Location Plan
- Figure 2 – Site Setting Plan
- Figure 3 – Aerial Photo and Layout
- Figure 4 – Detailed Coke Works Plan
- Figure 5 – Development Constraints Plan
- Figure 6 – Site Investigation Plan
- Figure 7 – Known Impacts Plan

Appendix B Collated Borehole and Trial Pit Logs

Appendix C Laboratory Data

Appendix D Gas Data

Version Log	Date	Amendment
1	10.10.2019	Initial Issue
2	25.10.2019	Revised following addition reports being made available.



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1.0. INTRODUCTION AND AIMS

1.1 Introduction

Geo² Remediation Limited (Geo²) were commissioned by Monckton Developments Limited to undertake a review of historical environmental investigation works undertaken at the former Monckton Coking Works facility.

Earlier investigation, undertaken by other parties, identified land contamination issues occurring as a result of historic activities including a coking works, stockyard, gasworks, quarrying and mining.

At the time of writing the site has ceased trading and has largely been demolished to slab level; in preparation of a proposed redevelopment programme.

1.2 Aims

This report aims to review the earlier works to ensure that potential land contamination issues have been identified and where present have been adequately characterised. Where gaps remain, this report will highlight the need for further characterisation works or for consideration within the framework of the proposed development.

1.3 Historic Reports

Geo² have been provided with the following reports for inclusion within this review. Details from these reports will be duplicated herein and referenced accordingly using the codes below.

Ref No	Author and Date	Report Title
1	Unknown	Monckton Data Comparison
2	RSK Group 2011	Environmental Risk Assessment 16492-R1 (01)
3	RSK Group 2013	Groundwater Sampling 321453 (H) L01 (00)
4	RSK Group 2014	Data Review of Monckton Production Facility 321789 (H)- R1 (00)
5	Patrick Parsons 2016	Ground Investigation Factual Report G15009
6	Unknown	Data Comparison Sheets
7	Patrick Parsons 2016	Remediation Strategy, G15009
8	Unknown	Coal Mining Risk Assessment
9	Met Engineers 2017	Flood Risk Assessment 12910-5005
10	Coal Authority Report 2015	Shaft Plans and Data Sheets 71000691050001
11	Moorhead Consulting 1994	Environmental Site Survey - 7102
12	WSP 2005	Environmental Due Diligence 12022228
13	Patrick Parsons 2015	Ground Investigation Report G15009
14	ABB 2002	Phase 1b/2 Site Report ILM092/1b-2
15	Coal Authority 2007	Coal and Brine Report 00102708-07
16	HBR	Protocol of Remediation
17	Patrick Parsons Feb 2017	Remediation Strategy G15009

Table 1: Historic Reports

It is clear that these reports do not represent all the works undertaken at this site and a detailed review has revealed gaps within the reports provided, available data has been used where present.

It is understood that the Client has been granted reliance upon only the Patrick Parsons reports (Ref 5, 7,13 and 17), which represent the most recent data for the site. All other data considered here will be used to aid and inform decision making but will not in itself be relied upon in this document.

2.0 SITE SETTING

2.1 Site Location

The site is located on Lund Hill Lane, Royston, to the northeast of Barnsley, South Yorkshire; at a National Grid reference of 437460, 412020, as shown on Figures 1 and 2 in Appendix A.

At the time of writing, most of the site has been reduced to slab, or sub slab level, with few structures remaining associated with the historical workings of the site, either in a state of dereliction or retained for maintenance and operation of utility supplies.

The former engineering workshop, on the eastern boundary remains operational as a leased unit and a portion of the land, also on the eastern boundary has been redeveloped into offices and car parking for Hargreaves Industrial Services plc.

The site is accessed from two main entrances along the eastern boundary, from Lund Hill Lane, the northernmost entrance allowing access through a weighbridge to the former stockyard and Engineering Workshops, the southern entrance allowing access to the Hargreaves property (which will be considered as offsite in this assessment) and an effluent treatment plant in the far south of the site.

2.2 Site Areas

For convenience many of the historic reports have separated the site into three key areas, divided by the current and historical activities which have taken place. These area designations and names will be adopted herein. The extents of each of these areas is shown on Figure 3, in Appendix A.

- Stockyard Area

The northernmost portion of the site; formerly occupied by the coke and coal stockyards. This area was the hub of the former colliery operations including numerous buildings and rail tracks.

- Former Production and By-Products Area

This forms the centre of the site including the Combined Heat and Power (CHP) infrastructure, coking ovens and conveyors. This area includes plant associated with production of tar, benzole and ammonia.

- Southern Area

This area contains the effluent treatment plant and is predominantly wooded with coarse vegetation and semi-mature trees. Much of this area slopes steeply to the south.

- Western Area

This area lies to the west of the railway lines. This parcel of land is understood to be out-with the boundaries of this site. It is understood that this area was formerly linked with a bridge to the main site and historically has been used for deposition of colliery spoil and more recently gas purification, storage and distribution.

2.3 Site Levels

The ground levels are generally highest in the Southern Area, the remainder of the site gently falls towards the north. The western and southern boundaries, slope steeply downwards into the railway cutting and road bridge level. In the north, northeast and northwest, the land level has been cut into the hillside where rudimentary retaining walls of tyres have been constructed.

2.4 Site Setting

The site is situated in an area characterised by former coal mining activities, at the time of writing little of this infrastructure remains active. Current nearby landuses are summarised on Table 2, below.

North	Agricultural land and commercial facility, approximately 120m to the north. Beyond which lie disused industrial and agricultural land.
East	Lund Hill Lane (B6428), beyond which lies grassed disused industrial land and a timber recovery facility.
South	Lund Hill Lane (B6428), beyond which lies former industrial land now Rabbit Ings Country Park.
West	Railway Cutting, beyond which lies agricultural land and residential properties approx. 120m beyond the site boundary. The Barnsley Canal lies approximately 200m to the west.

Table 2: Surrounding Land Uses

2.5 Sensitive Receptors

Reports have not identified any land use designations, such as SSSIs or similar. Areas of green belt are present in the surrounding land and the site falls within a Nitrate Vulnerable Zone.

3.0 SITE OPERATIONS

This section draws on content from within the RSK 2014 report (Ref 4) and Moorhead Consulting report 1994 (Ref 11) which cover the industrial processes which occurred during the operational life of the site. This allows identification of potentially contaminative activities and highlights areas of concern to be cross-referenced subsequently with the existing investigation data.

3.1 Stockyard and Former Colliery

This area is currently level and largely demolished to slab level, with the exceptions of the Engineers Workshop building and occasional small structures. The former structures in this area were used as workshops, mobile plant refuelling, effluent handling and storage.

The bulk of the stockyard was used for the storage of coal, with approximately 100No. twenty tonne lorry movements delivering coal and removing coke from the site daily during operations. Tipped coal was lifted from stock and conveyed to a 1,300-tonne storage bunker, before being conveyed to a 500-tonne bunker and into the coke ovens. This area appears surfaced with a thin layer of black coke dust 'breeze'; this is clearly apparent in the aerial photo used in Figure 3. This has been further considered in Section 9.0.

In the northwest corner of the site remain a series of Quench Ponds which appear to remain intact and holding water.

Three mine shafts are understood to be present in this area, records indicate these have been capped. Further details with respect to mine shafts is included in Section 13.0.

A portion of the stockyard area, labelled on Figure 3 as 'Unused Area' is present at a higher level, matching the height of the surrounding land beyond the northern boundary. This area appears to be vegetated.

The engineering workshop was situated adjacent to a waste storage and collection area. A substation is also indicated to be in this area.

Currently large stockpiles of high silica content brickwork associated with the demolition of structures onsite remain present on the site.

3.2 Production and By-Products Area

The central section of the site forms the Production and By-Products area. This area is understood to have been used for the production of coke and associated products for over a century.

3.2.1 Coke Production

Figure 4, in Appendix A, shows a layout drawing of the Coking Works (drawn from Ref 4), onsite this process comprised coal carbonisation. Carbonisation is the thermal process for the conversion of coal into coke, involving a sustained high temperature in ovens for eighteen hours in the absence of air. On this site five batteries of ovens (42 in total) were located at the northern boundary of this area, adjacent to the stockyard giving access to coal.

The coal is heated indirectly through heat transferred through the refractory walls from flues running along each long wall, in which coal gas is burnt under controlled conditions in air. The coal gas produced is collected in a gas collection main. Recovered gas used to fire the ovens is a portion of that drawn from the coal during carbonisation. Recovered gas is purified and added to a preheated air stream back into the ovens.

Once heating is complete, coke is pushed by a ram into a rail mounted coke car. Exposure to the atmosphere allows the coke to burn, which is extinguished using a quenching rig at the rear of the ovens.

Coke is screened and cut to size at the Coke Wharf before transport back to the Stockyard area.

3.2.2 By Product Processing

Pre-treatment of coal gas results in the generation of a series of by-products, used in the coke works process.

Gases recovered are treated in the Concentrated Ammoniacal Liquor plant. The gas collected from the main is cooled using five heat exchangers (Primary coolers), this separates out the tar and ammoniacal liquor. Tar is separated from gas using an electrostatic detarrer for storage and resale. Ammoniacal liquor is separated by ammonia washers, spraying water through the gas. The gas then passes through Benzole Scrubbers where wash oil recovers the benzole (a mix of benzene, toluene and xylenes). The wash oil is distilled with steam to recover the benzole as a saleable commodity. Vapours are condensed to give a saleable product with approximately 20% ammonia and 2% sulphide.

60% of the cleaned gas is used onsite in the CHP supplying steam and power for the works. Surplus power is sold on the National Grid. Treated gas was stored onsite in a 1,400m³ capacity gas holder.

Treatment is understood to have comprised mixing effluent with biological sludge and oxygen to degrade organic compounds to carbon dioxide.

More recent reports suggest that an electric substation may also be present close to an area of removed Ammoniacal Liquor tanks near to the gasholder.

3.3 Southern Site Section

This area has generally had few industrial applications and contains the Biological Effluent Treatment Plant.

The stripped liquor is pumped to a biological effluent treatment (BET) plant, which is used to treat drainage prior to discharge to sewer. It is understood that this plant also treated water from Lineside Dyke on the western boundary of the site.

The steeply sloping land levels and terraced areas of this portion of the site are noted to be suggestive of infilling (Ref 4) with colliery spoil.

3.4 Western Land Parcel

This parcel of land falls out with the boundary of the site, although records indicate the deposition of colliery spoil and uses in the purification, storage and distribution of gas produced on the site.

Ref 4 suggests that remediation of this parcel of land was undertaken circa 2004 although no details have been made available to Geo² for comment.

4.0 SITE GEOLOGY

4.1 Reported Geology

The underlying bedrock geology has been reported as Undifferentiated Carboniferous Middle Coal Measures, comprising Mexborough Rock sandstone, beneath the majority of the site, apart from the north and southernmost parts. No superficial deposits are listed on BGS records.

The Royston Coal Seam outcrops beneath the site in the south of the site at a shallow depth. This area has been reported (Ref 5) as falling within a Development High Risk Area, with reference to potential historic shallow mining.

Intrusive investigations undertaken by various parties encountered Bedrock at depths of between 0.5-4.5mbgl, placed directly underlying Made Ground deposits (Ref 13). Bedrock primarily comprises Sandstone, however Mudstone was encountered in the northeast, south and central eastern parts of the site.

Records indicate excavation of clays have occurred in the north of the site, with Sandstone quarrying in the southeast (understood to be beneath the existing Hargreaves Industrial Services plc premises).

Rotary drilling demonstrated interbedded sequences of sandstone and mudstone to a maximum achieved depth of 30mbgl. The presence of coal shafts in the north of the site, is suggestive of productive seams at a greater depth in this area.

4.2 Hardstanding

The majority of the production and by-product areas as well as the eastern portion of the stock yard are surfaced with unreinforced and reinforced concrete, of between 200-500mm in thickness.

4.3 Made Ground

Made ground has been encountered across the entire site in all earlier investigation works to a thickness of between 0.2-4.0mbgl.

In the northern stockyard a 'mantle' of coal was present at between 0.2 to 1.1m in thickness (Ref 13) associated with breeze coke dust., this material is of high calorific value as detailed subsequently in Section 9.0.

The east of the stockyard is underlain in parts by reworked topsoil's, which are also present across much of the production and by products area. This material is noted to include fragments of coke, coal and brick.

Made ground mainly constitutes a very loose, medium dense ash based GRAVELLY SAND, with variable content of clinker, cinder, coke, brick, concrete, mudstone and sandstone (colliery spoil).

Cohesive areas of clayey made ground were encountered within the bulk of the granular made ground deposits.

4.4 Superficial Deposits

Limited information is available detailing the presence of natural soils beneath the site, likely due to the degree of industrialisation which has occurred on the site over the years. As a result, natural superficial deposits have only been encountered in the extreme northern and southernmost parts of the site at depths of between 0.4-3.0mbgl (Ref 13).

These deposits generally comprised firm to stiff gravelly clays, however soft organic clays were proven in the extreme north of the site.

Limited evidence of natural granular soils was reported, where encountered there are considered to be the result of insitu weathering of underlying coal measures (Ref 5).

5.0 HYDROGEOLOGY

5.1 Aquifer Vulnerability

The underlying bedrock has been designated as a Secondary A aquifer (Ref 4), there is no designated groundwater within any superficial deposits.

Groundwater vulnerability mapping indicates that the site has a high leachability potential, although it should be noted that this is due to poor data coverage in the area and is a worst-case scenario.

Comments in the RSK report 2011 (Ref 2), indicate that the shallow groundwater encountered is not considered to be a continuous body across the site. A comment in the same report characterises the shallow groundwater as *'discrete pockets of shallow, perched, groundwater, were encountered within the made ground...at these locations the saturated horizon was found to directly overlie the sandstone bedrock, with no impermeable horizon in between.'* The report states that it is 'likely that surface waters and perched groundwater will infiltrate vertically into the sandstone bedrock and impact the groundwater within.

Deeper boreholes suggest a potential groundwater flow direction within the deeper groundwater within the sandstone bedrock towards the north (Ref 2), assuming a single continuous water body is present beneath the site. Although other reports (Ref 4, Ref 14) suggest no clear groundwater flow direction and the potential for multiple groundwater bodies.

5.2 Groundwater Monitoring Data

Numerous boreholes have been installed and monitored across the site in the various phases of investigation, Table 3, below summarised reported dip and strike data from a series of boreholes across the site. The locations of these sample points are shown on Figure 6, in Appendix A.

These works all predate the recent demolition works at the site and as such Geo² would assume that these boreholes no longer survive.

Area	BH ID.	Free Phase Product Thickness (m)	Depth to Water (mbgl)		Depth to Base (mbgl)
			2011 (Ref 2)	2013 (Ref 3)	
Stockyard	BH201	-	6.127	6.82	12.58
Stockyard	BH202	-	11.418	11.88	20.19
Production	BH203	3.40m DNAPL	9.66	10.11	14.19
Production	BH204D	-	8.925	6.60	14.35
Production	BH204S	-	Dry	dry	dry
Production	BH205	-	8.171	8.74	22.79

Table 3: Groundwater Dip Data

Dense Non-Aqueous Phase Liquid (DNAPL) was encountered in BH203 in 2013, with a response zone targeting the mudstone, this was not noted in 2011. Following removal of approximately 25 litres of NAPL from BH203, this was observed to recharge to a similar thickness within 24 hours. This product has been tentatively identified as Coal Tar.

The RSK 2011 report (Ref 2) also dip a series of PH wells (PH101-PH111- locations unknown) these each encounter groundwater between a depth of 0.784mbgl-11.418mbgl.

6.0 HYDROLOGY

There are a number of local surface water courses to the site, including the following, drawn and updated from the 2005, WSP Due Diligence assessment (Ref 12).

Water Feature	Quality	Distance	Direction
Lineside Dyke	Unclassified	Adjacent to the northern part of the western boundary of the main coking works site. Flows in a generally southerly direction joining Cudworth Dyke approximately 140m to the south of the site.	
Wakefield Brook	Unclassified	Within 10m of the western boundary of the former gas purification area (the western parcel of land), approx. 100m from the current site boundary, close to the Barnsley Canal. Flows in a southerly direction, joining Cudworth Dyke, approximately 220m south of the site.	
Cudworth Dyke	Unclassified	Located approximately 140m to the south of the site. This flows in a southerly direction, joining the Sandybridge Dyke to become Poole Dyke. Eventually flows into the River Dearne approximately 5km south of the site.	
Barnsley Canal (disused)	'F' or 'poor'	35m	West

Table 4: Surface Water Features

Reports suggest that abstractions had been made from these water courses during the operational life of the site, none of which remain active currently.

The Moorehead Consulting report (Ref 11, 1994), suggests that discharges were made from the site during its active life to the Barnsley Canal.

The 2002 report (Ref 14) indicates that the presence of a railway cutting along the western boundary may affect local groundwater flow and suggests a component of flow to the west along the site margin. This is consistent with observations (ARP 2002) of leachate discharges along the steep western bank.

7.0 SITE HISTORY

7.1 Historical Map Review

In addition to the recent industrial history of the site, as discussed in Section 3, consideration is to be given to historical potentially contaminative land uses on and near to the site identified from a review of historical maps and reports.

The following summary of potentially significant activity onsite and in the nearby area is drawn from the RSK 2014 Data Review and 2005 WSP Due Diligence Report (Refs 4 and 12). Copies of historical maps are present in Ref 12; the following summary is drawn from the text of the reports.

Year	Description
1854	The site and surrounding land are shown as undeveloped agricultural land. A railway is present in its current location and the Barnsley Canal is shown.
1874	Monckton Main Coal Colliery Limited is established.
1875	A 'Clay Mill' was established and sinking operations associated with two shafts started, completed in 1878.
1879	Twelve beehive ovens were established.
1884	The by-products plant and ten ovens were established.
1886	Erection of gas plant occurs.
1893	Monckton Main Colliery occupies the northern part of the site, comprising coke ovens, shafts and railway tracks. A gasworks is located to the southwest of the site (described as being in the location of the current effluent storage tanks). A mineral railway is present in the east of the site which runs to the northeast corner of the site. Two powder magazines are noted in the central portion of the site. A small old quarry is located in the south east part of the site. Deposited colliery spoil is marked in the north of the site and waste materials have been tipped in the area of the current By-Products area. The southern end of the site is shown as containing terraced housing and a Methodist Church. At this time the western parcel of land is shown as a Spoil Heap and is connected to the Main site by a railway line. Spoil is also shown as having been tipped across much of the low-lying area in the west of the site.
1906	Monckton Main colliery has expanded within the northern part of the subject site. Additional coke ovens and rail lines have been developed with filter beds (in two locations close to the railway), above ground tanks and a waste spoil heap also present. The powder magazines are no longer shown. The gas purification area is now occupied by a gasometer and spoil heaps. The northeastern area is no longer shown as a brick works, although kilns are still present. Offsite, the western parcel of land shows a single gasholder.

Table 5a: Site History

Year	Description
1917-18	The coke ovens are shown in their current location, with a number of features in the by-products area labelled as tanks. A railway line indicated on earlier plans is shown as running within a tunnel. In addition to the two mine shafts a third air shaft is shown close to the centre of the site. The gasworks is no longer shown on the site, or on the western parcel of land.
1932-33	Spoil heaps are shown associated with the onsite colliery, which extend offsite to the east, onto the Rabbit Ings site and to the north. Two circular features are shown on the southern part of the western parcel of land.
1962	The northern part of the site is labelled as a mine, with a large building with railway track connections located on the northern boundary. This is linked to the Works in the centre of the site. Water tanks are shown on this plan, consistent with the location of the existing Quench ponds in the North West. The mine appears connected with buildings to the East of Lund Hill Lane. The western parcel of land has become annotated as Works also. Distinct areas of tipping have expanded into the neighbouring land to the north and east.
1970	The Benzole Rectification Plant closed and demolished, and shafts infilled and concrete capped.
1980	The Biological Effluent Treatment Plant is constructed.
1981	The site has been rationalised, with a number of buildings and railway lines associated with the mine no longer apparent. The mine itself is listed as disused. Residential properties in the south are no longer present. Spoil heaps offsite, to the north are now labelled as active workings and land to the east of Lund Hill Lane is now shown as a drift mine.
1990	The number of structures on the site is shown to decrease, with buildings in the north of the site shown to have been removed.
1994	The railway lines have been removed from the site.
2006	The office block and CHP plant (built 1998) are shown in their current configuration. Offsite spoil heaps are now shown as wooded or parkland and the drift mine is no longer shown.
2014 onwards	The site is largely in its current configuration, with demolition and stockpiling of materials from the coke ovens.

Table 5b: Site History

7.2 Historical Walkover Notes

Site walkovers undertaken whilst much of the plant remained active allows a more detailed appraisal of potential contaminant sources on the site, these comments are drawn from Ref 4, but attributed to Ref 14 and Ref 2 from 2001, 2011 and 2014 respectively.

7.2.1 Walkover: Production Area

The Production area was observed during the walkover to be heavily stained, with indications of recent diffuse and point releases. The condition of some plant was found to be poor with, for example, leaking pipework, leaking valves and pumps, leaking tanks and indications of severe corrosion.

Surface water gullies in the area collect liquors escaped from equipment, and in some cases appears blocked and overflowing.

7.2.2 Walkover: Ammonia Production Area

The ammonia production area (See Fig 4, in Appendix A) was noted to be in a poor state of repair (2011) with damaged vessels, exposed lagging and corroded interconnecting pipework observed. There was evidence of spillages in the vicinity of a number of loading / unloading points and damaged infrastructure. Concrete hardstanding was noted to be damaged in many places.

Bunding around hydrochloric acid and caustic soda tanks was constructed in blockwork and there was evidence of staining due to leaks and spills. Bunded areas were noted to contain significant quantities of coloured unidentified liquids. Bunding at the western end of the by-products production area was noted to have blue staining in some places associated with the presence of cyanide. Many bunds are reported as not appearing to be in good condition.

Site representatives indicated that pipework carrying effluent from the ammonia plant to the biological treatment plant (in the south of the site) had leaked a number of times in the past but had been replaced.

7.2.3 Walkover: CHP Plant

The Combined Heat and Power Plant (CHP), in the southeast of the site, which remains onsite, was noted at the time to be relatively modern and in good condition. Ground staining in the northwest corner of the building was noted as were the operative clean boiler parts.

Records suggest that a 500m deep borehole was installed to the west of the CHP plant as a means of testing the possibility of extracting coal gas methane. It is unclear as to whether this remains or was decommissioned.

7.2.4 Walkover: Workshops

The Engineers Workshop, which remains active to date, is located in the north-eastern corner. A second Workshop was located centrally. Both were noted to contain various oil containers and had a heavily stained floor.

7.2.5 Walkover: Stockyard

In 2014 the stockyard was still used for the storage of coal and coke. The northern boundary of this area is formed largely from a tyre bund retaining wall supporting a higher land level to the north, northeast and northwest.

The north east of the site, labelled as unused land, is shown to be marshy and heavily vegetated with evidence of Japanese Knotweed, see Section 14.0. This area is shown as between 4.0-5.0m higher than the surrounding land and is reported as being a soil bund containing brick and concrete.

7.2.6 Walkover: Substations

Electric substations are noted onsite in the By-Products Processing Area. It is reported that transformers were changed and relocated onsite in 1986 (ref 11). Subsequent tests for PCB contamination have been carried out every two years by Yorkshire Electricity and no contamination is noted as having been found.

Monckton Coke and Chemical Works (MCC) staff reported that no PCB containing materials are present onsite (Ref 12), but states that no documents were available to demonstrate PCB removal.

7.2.7 Walkover: Tanks

A number of Above Ground Storage Tanks were located at the site, predominantly associated with the By-Products Plant. A double skinned diesel tank was noted in the Stockyard in 2014, used for the fuelling of onsite plant.

MCC representatives report that no Underground Storage Tanks (USTs) were present at the site. Although effluent storage ponds are understood to be below ground structures, with buried connecting plastic pipework.

8.0 SUMMARY OF INVESTIGATION WORKS TO DATE

This section aims to summarise the intrusive investigation works undertaken to date into each of the three sections of the site. This information will inform a review of the conceptual site model and enable an appraisal of how well identified sources have been characterised to date.

Reviewed reports contain the following investigation works, all sample points where known are included in Figure 6 in Appendix A and data is included in Appendix C:

Ref No	Author and Date	Report Title	Investigation
2	RSK Group 2011	Environmental Risk Assessment 16492-R1 (01)	Six groundwater samples collected predominantly from the Production and By-Products Area. (BH201-BH205 and PH108), drilled as part of the 2011 works.
3	RSK Group 2013	Groundwater Sampling 321453 (H) L01 (00)	
5	Patrick Parsons 2016	Ground Investigation Factual Report G15009	Excavate 33 Trial Pits to replicate the 2002 and 2015 ABB (Ref 14) and PP (Ref 13) trial pit locations. Trial Pits names TP1001-TP1033. Locations of the TP1000 series are equivalent to those shown on Figure 6 for the corresponding TP100 series (e.g. TP1104 = TP104 and TP 1005 = TP5). In addition to soil sampling grab samples of groundwater were obtained from TP1006 and TP1010. Groundwater samples were obtained from BH301-BH305, Surface water locations SP1-3 and WS9. Sample points are spread across the Stockyard and predominantly west and south of the Production and By-Products area, with limited investigation into the Southern Area.
13	Patrick Parsons 2015	Ground Investigation Report G15009	Excavate Trial Pits to replicate the 2002 ABB trial pit locations. Included the advancement of TP6-TP28, TP101-TP109, WS7-WS9. Groundwater samples were obtained from BH301-BH305, RBH1D-RBH5. Sampling occurred to a similar distribution as the above.
14	ABB 2002	Phase 1 +2 report. ILM092/1b-2	This included an investigation comprising 33 Trial Pits (TP1-33) and 7 monitoring wells (MW1-MW6A), surface water sampling from across the entire subject site. Appendices are missing from this report.

Table 6: Investigation Works Summary

For ease of interpretation the works undertaken, and results have been split down into each of the three sections of the site.

Where concentrations of contaminants have been referred to as elevated or in excess of GAC, this refers to comment from the parent source and have not been characterised independently by Geo².

8.1 Investigation: Stockyard

Geo² have been provided with copies of Trial Pit logs for excavations across the stockyard area, as this area which include TP1-5 (Ref 5), TP32-33 (Ref 13), TP102-TP110 (Ref 13) and TP1102-TP1110 (Ref 5), copies of which are included in Appendix B.

Trial pit logs encountered evidence of the 'breeze' mantle consistently across the Stockyard area, referring to this as coke and ashy material to thicknesses of typically 0.3-0.6m, extending in some areas as deep as 1.0mbgl.

This material was found to overly Made Ground comprising coarse granular rubble fill of bricks, coke, coal and ash to depths of between 1.8m->3.0mbgl.

Natural soils comprise, weathered sandstone encountered as sands or gravel deposits to a depth of 0.7-2.7mbgl.

Sandstone was encountered from 0.2m-3.0mbgl across the Stockyard, with the exception of the far north where Mudstone was encountered in (TP32) from 1.4mbgl in an area identified as the former Clay pit.

8.1.1 Analysis of Breeze

The surface cover of breeze has been noted as having a high calorific value, testing also indicated the presence of Chrysotile asbestos in this material in the top 0.5m, in the north of the site. Sampling at greater depth (0.5+m) and from elsewhere in the Stockyard did not identify any asbestos.

Laboratory analysis of the Breeze was undertaken for TPH, VOC, SVOC (inc. PAH), metals and inorganic parameters. This material appears to contain some elevated concentrations of PAH, concentrations of hydrocarbons and other analysed determinants were considered to be relatively low in concentration. Laboratory certificates are included in Appendix C.

Calorific content of this material is included in Section 9.0.

8.1.2 Stockyard: Analysis of Made Ground

Many of the trial pits have been undertaken to achieve comparative results with earlier rounds of analysis, as a result whilst a reasonable number of trial pits have been established onsite the frequency of non-targeted testing is quite low in certain areas of the Stockyard, in particular around the southern portion of this area, close to the Engineers Workshops and entrance.

Analysis, undertaken for TPH, VOC, SVOC (inc. PAH), metals and inorganic parameters, identified some potentially significantly elevated concentrations of PAH compounds (TP106, TP108) and infrequent high concentrations of Lead (TP109), likely to be associated with the composition of the made ground, rather than any particular point source. Laboratory certificates are included in Appendix C.

No assessment has been made of the 'Unused Area'.

8.1.3 Investigation of the Clay Pit

The site history indicates a former clay pit along the northern boundary, as shown on Figure 6, in Appendix A. records from TP31, TP32 and TP107 in this area indicate bedrock (or concrete

obstruction TP107) to be present at 0.2-1.4mbgl in this area. This suggests that much of the removed clay has been taken from above the existing site level, explaining the reduction in land level over the surrounding land to the north.

Testing of the limited thickness of Made Ground, undertaken for TPH, VOC, SVOC (inc. PAH), metals and inorganic parameters, does not suggest any significant impact. Laboratory certificates are included in Appendix C.

8.1.4 Investigation of the Railway Tunnel

The historical records indicate a railway tunnel located beneath the Stockyard, running from the southwest of this area to the north east, as show on Figure 6, in Appendix A.

Whilst Geo² are not aware of any visual evidence of the location of this route, corroborating evidence is supplied by the following obstructions encountered in the following Trial Pits:

- TP102. Numerous concrete obstructions were logged in this location, with a failure on a concrete slab at 1.8mbgl (Ref 13).
- TP4: This Trial Pit terminated on a concrete slab at 3.0mbgl (Ref 5).

Relevant logs are included in Appendix B.

Geo² consider the available data to be insufficient to characterise whether any void or former tunnel remains in this area.

8.1.5 Stockyard: Assessment of Groundwater

Groundwater samples have been obtained from RBH1-3 all in the Stockyard, each of these wells was installed into the underlying bedrock, classified as Mudstone (Ref 13), with a response zone in this formation, no dip data has been made available, however strike readings at approximately 12.0m- 13.5mbgl have been observed. Analysis of these samples for TPH, VOC, SVOC (inc. PAH), metals and inorganic parameters does not indicate any elevated concentrations within this body.

BH302 and BH303, in the east and west of the Stockyard area, respectively, are also similarly installed, but characterise the underlying bedrock as Sandstone. These samples similarly exhibit low to no evidence of contamination within these deposits.

BH201 and BH202, sampled in this area, encountered groundwater at 6.1m and 11.4mbgl respectively. Geo² have no details of the manner of installation of these wells. Analysis has been undertaken in 2011 and 2013 (Ref 2 and 3, although only data from Ref 3 has been made available). Testing or TPH, VOC, SVOC (inc. PAH), metals and inorganic parameters does not suggest any elevated contaminant loading in these locations.

Laboratory certificates are included in Appendix C.

8.2 Investigation: Production and By-Products

A review of this area indicates that sizeable areas have experienced very limited assessment, most likely due to the ongoing operations in these areas.

Walkover inspections, as detailed in Section 3, identified many discrete potential point sources in this area, along with potential historic features which have been replaced over the operational life

of the facility. As such, Geo² consider a higher density of sampling would be required in order to adequately characterise potential impacts in this area.

A review of Trial Pit and Borehole Logs from TP6-TP26, TP101, BH203-BH205, BH301, BH304-305, predominately undertaken in the west and south of the area, encountered Made Ground consistently across the area, to depths of between 0.6m-2.5mbgl. This material was found to uniformly comprise a mixed granular rubble fill of bricks, coke, coal and concrete in a sandy matrix, supplemented with more irregular inclusions from demolition waste. Obstructions were noted in 3 trial pits across this area due to concrete obstacles.

In the north western corner of this area, adjoining the Stockyard, the mantle of Breeze was noted to extend slightly across this area (TP101 and TP6).

Natural superficial soils were encountered infrequently along the periphery of the site and comprised weathered Sandstone

Underlying bedrock was found to comprise Sandstone.

8.2.1 Production and By-Products: Made Ground Analysis

A number of Trial Pits along the western site boundary were observed to contain strong visual evidence of contamination with oily or tarry liquids noted seeping in TP101, TP11, TP13, TP21-TP22, and within infilled basements of the exhaust house found encountered in TP16.

Analysis of these locations, plus TP6, TP14, TP17-18, TP20, TP23, TP24-25, indicated that the soils contained oils and tars with very high PAH concentrations. With associated hydrocarbons noted in TP13, TP21 and TP22. Figure 7, in Appendix A, delineates the areas of known PAH and tar contamination.

Remaining areas demonstrate little evidence of land contamination although it should be noted that coverage around the gasworks plant remains limited.

8.2.2 Production and By-Products: Groundwater Analysis

BH203-BH205, RBH4/4A, BH301 and BH305 were all installed in the Production and By-Products Area. Analysis of these samples for TPH, VOC, SVOC (inc. PAH), metals and inorganic parameters produced the following results. Figure 7, in Appendix A, shows the areas of known groundwater contamination in this area.

BH203, located along the western site boundary was noted in 2013 to exhibit several metres of DNAPL with very minimal water recorded above. Analysis of this product indicated it to be a PAH compound, most probably Coal Tar. No DNAPL has been observed elsewhere at this time, although untested black tarry products were noted in the 2002 report (Ref 14) in MW5 and MW6.

BH204 and BH205, encountered groundwater at a depth of approximately 8-9mbgl, both were observed to exhibit potentially significant concentrations of hydrocarbon and PAH contamination.

RBH4/4A was installed into the underlying Sandstone with a response zone between 14-18m, and a groundwater strike at 13.9m. Testing revealed trace concentrations of hydrocarbons in the groundwater in this location.

BH301 and BH305, both are installed into the underlying sandstone located beneath a mudstone horizon present between approximately 15-25m in depth, with groundwater strikes at approximately 23m and 25mbgl. Analysis of these samples for TPH, VOC, SVOC (inc. PAH),

metals and inorganic parameters demonstrated low to no contamination in BH301 and slightly elevated concentrations of hydrocarbons and PAH in BH305.

8.3 Investigation: Southern Area

The southernmost area of the site has the least evidence of industrial development and activity. Investigation in this area has predominantly targeted the existing BET plant.

Geo² have no data from WS7-9 and WS10, although logs indicate Made ground comprising predominantly reworked natural clays with occasional evidence of coal or coke to depths of upto 2.0mbgl.

This overlies natural sandy clays, to depths of at least 5.0m. Although it should be noted from the historical maps that the periphery of this area is likely to contain tipped spoil material, the boreholes do not extend into these areas.

RBH5, listed as encountering mudstone from 0.7mbgl in this area, was installed to permit groundwater sampling from a response zone of 12.0-16.0mbgl within this deposit. Rest water level was dipped at approximately 14.0m bgl, analysis of this sample for TPH, VOC, SVOC (inc. PAH), metals and inorganic parameters did not suggest any significant evidence of land contamination.

9.0 CALORIFIC VALUE

Sampling of the shallow mantle of 'breeze', the darkly coloured coal bearing made ground located across the Stockyard area was undertaken in the 2015 Patrick Parsons Investigation (Ref 13).

This comprised eight samples which were tested for calorific value to determine the hazard this material may present through its flammability.

The eight samples reported calorific values of between 0.4 and 18.4MJ/kg. Five samples exceeded 6MJ/kg and two of which exceeded 10MJ/kg. Values in excess of 2MJ/kg are considered combustible. Only one sample, from TP106, in the extreme north of the Stockyard fell below the 2MJ/kg value. On this basis Geo² would assume that all this breeze material across the Stockyard and where encountered on the approach to the Production and By-Products areas should be considered potentially flammable.

10.0 OBSTRUCTIONS

Investigation works to date have been undertaken at various stages of demolition of the site, it is considered likely that many underground obstructions remain unencountered following demolition of much of the site.

Despite the demolition of much of the site to slab level significant below ground obstructions should be anticipated. Historical reports (Ref 5 and 13) mention multiple obstructions associated with concrete and brick foundations to 1.0m and 2.2mbgl in the coke works area and 0.6m-0.9mbgl in the By-Products area.

The stockyard contains buried remnants of concrete foundations and substructures between 0.4m-3.2mbgl.

The presence of drains and other services was also noted.

The Patrick Parsons 2017 report (Ref 17), listed remnant buried foundations and substructures as a significant hinderance to earthworks and foundation construction and stated that these should all be grubbed up. Geo² consider that the relict structures will present a significant obstruction to further site characterisation which should be considered in future site assessment works.

The site history section of this report and comments in the 2017 Patrick Parsons report, indicates the presence of potential underground railway lines running within a tunnel, the proposed location of this is shown in Figure 5 in Appendix A.

The presence of concrete capped coal shafts, as detailed in Section 13 should also be considered.

11.0 GROUND GAS

A number of ground gas sampling rounds are reported as having been undertaken in previous ground investigation works, although only one data set has been made available, from 2016 (Ref 5). Samples were taken from six boreholes across the Production and By-Products area (BH301, BH304, BH305, RBH4 and RBH4A) a single sample was obtained from WS5 in the Stockyard Area.

The reported data, included in Appendix D, reports no Methane, with CO₂ between 1.4-8.4%. This data is insufficient to allow any meaningful characterisation of ground gas from below the site, Geo² cannot also attest to the suitability of the boreholes for this purpose or to the targeting of any clear gas source.

Ref 2, 2011, indicates that further ground gas testing has been undertaken, however results have not been made available. This report acknowledges the limited characterisation of the gas regime beneath the site and potential outstanding risk this presents.

Ref 13 lists ground gas generation potential of the deep Made Ground on the site as being a potentially significant source. Consideration should be given to the potential gas generation associated with mining and shafts present on the site and potential infilling in the property.

12.0 ASBESTOS

It is likely that asbestos containing materials (ACMs) were present within numerous structures on the site throughout working life and may remain within structures present onsite today.

As a result of this it is considered likely that asbestos may remain within made ground on the site and potentially within tipped materials, potentially within the infilled sandstone quarry (in the location of the current Hargreaves property) and also in the infilled brick pits in the north of the site.

12.1 Asbestos Inspections

A note in Ref 12 indicates that a Type 2 Asbestos Survey has been undertaken in 2004 (although a copy has not been provided). It is not clear how much of the site this addresses and due to its age, this would not be compliant with Control of Asbestos Regulations (CAR) 2012 and the current Asbestos legislation. However, it is worth noting that this report presumed (but did not test) on the basis of a visual inspection the following indications of asbestos on the site:

- Roofing materials on brick shed, exhaust house, old garage, coke screen house, old warehouse, stores, pump house, CAL plant, predominantly (but not exclusively) in the Production and By-Product areas of the site.
- Side panels of the exhauster house and coke screen house in the Production area.
- Possible gasket material on an old boiler and evidence of similar gasket material over the entire site.

12.2 Asbestos Sampling of Soils

Sampling of shallow soils undertaken in an earlier report (Ref 13) with assessment for asbestos. 4 samples of 15 were found to contain asbestos. Unbound chrysotile fibres were positively identified within 2 samples in the north of the stockyard (TP107 and TP108).

Two samples (Both from TP20- see Figure 6) from the Production and By-Products area was found to contain unbound Amosite and Chrysotile.

13.0 COAL RISK

13.1 Coal Authority Search

Coal Authority searches, most recently undertaken in 2014 (Ref 4), indicates the following:

- The site is underlain by 11 mined seams of coal at depths of between 100 to 520mbgl, last worked in 1982. It is stated that any associated ground movement should have now stopped.
- There are three known mine entries on the site.
- The site has not been subject to any reported open cast coal mining works.
- No instability or mine gas has been reported to the Coal Authority

13.2 Mine Shafts

Coal Authority records (Ref 6 and 15) identify the following three shafts to be present on the site. These are summarised below in Table 7.

Shaft Location	Name	Depth	Capped	Capped By
437412-002	New Monckton Colliery No 2 Shaft	446.2m	12x 12x 1m reinforced concrete	British Coal. Feb 1989
437412-003	New Monckton Colliery No 6 Shaft	489.2m	15x 15x 1.2m reinforced concrete	British Coal
437412-001	New Monckton Colliery No 1 Shaft	450.8m	12x 12x 1m reinforced concrete	British Coal

Table 7: Mine Shaft Decommissioning Detail

The approximate locations of each of these shafts is shown on Figure 5, in Appendix A. The precise location of these should be identified and factored accordingly into any proposed development.

The RSK report (Ref 4) indicates that the capping works detailed above were initially undertaken in 1966-76 and following revision to the guidelines for shaft capping all three were recapped in circa 1994 with 20m x 20m x 2m thick concrete slabs.

Mine shafts have been located to the following coordinates (Ref 17), although no Shaft ID has been provided to correspond to these points:

- SE 37505 12187. N412187, E 437505
- SE 37431 12221. N412221, E437431
- SE 37430 12159. N412159, E437430

13.3 Subcropping Coal Seams

BGS Geological maps records the Royston Coal to subcrop in the extreme south of the site and it is anticipated to be present at a shallow depth in this area (Ref 8). As a result of this, a portion of the site, as indicated on Figure 5, in Appendix A is listed as falling within a Development High Risk Area.

Review of limited available borehole logs in this area (RBH5, Ref 5 and WS7-10, Ref 13, included in Appendix B), indicate bedrock to comprise of interbedded mudstone and sandstone from 0.7mbgl to in excess of 16.0mbgl, no coal deposits were noted in any of these four locations.

This data is quite spatially limited, all points are around the BET plant and do not cover the Southern Area more widely. Subcropping of coal deposits or voids, may produce localised instability or provide a pathway for ground gases to reach the surface.

14.0 INVASIVE SPECIES

Early investigations noted the presence of Japanese Knotweed within the extreme northwest of the site (Ref 13), as indicated on Figure 5, in Appendix A.

Investigations made available to Geo² do not enter into detail with regard to the extent of the Knotweed onsite. Geo² will assume the knotweed remains in this area and would recommend that Knotweed eradication specialists are approached either to kill off or remove this issue.

15.0 RADON

The Envirocheck reports (reviewed 2014) indicate that the site is located within an area where more than 1% of homes are above the Action Level, as defined by the National Radiological Protection Board.

Should the site be considered for future residential development, further assessment will be required in line with the guidance provided in BRE 211, "Radon: Guidance on Protective measures for New Dwellings (2007)".

16.0 SILICATE BRICKS

A large stockpile of bricks remains in the Stockyard area associated with the demolition of the Coke Ovens and ancillary structures.

A potential health and safety issue was noted with regards to the high silica content of these bricks, which when broken, cut or crushed, would release silica dust particles (Ref 7). Silica particles are respirable and have the potential to cause long term health issues.

A detailed study of the bricks indicates that these could be suitable for retention on site as part of a future development, subject to its end use. However, the presence of high silica content must be considered within the Remediation Strategy and wider development masterplan.

17.0 BURIED CONCRETE

Analysis of shallow and deeper soils has been undertaken in numerous reports, Ref 13 states the following:

- A class DS-4 AC-5 classification for Made Ground
- A class DS – 2 AC3z for natural soils may be assumed.

These classifications have been stated as in accordance with BRE Special Digest 1: 2005, assuming mobile groundwater conditions.

18.0 FLOODING

An assessment of the site has been made on the basis of a proposed residential end use by MET Engineers (Ref 9).

This report concludes that the site is located in a Zone 1 area and can present an allowable development in line with the commitments of the NPPF and Barnsley Development Plan providing that:

- Surface water flows can be regulated to ensure land does not generate an increase in flows as a consequence of the development.
- Post development storage, with a 30% climate change uplift, has been calculated to 3,241m³ for a 1 in a 100-year event in the north and 540m³ in the south, based on a discharge of 5 litres/second/hectare.
- Gravity discharge to a watercourse appears to be possible.

19.0 CONCEPTUAL SITE MODEL AND GAP ANALYSIS

UK legislation and guidance on assessing potentially contaminated land recommends the use of a risk assessment process based on a review of source/pathway/receptor relationships for various environmental media. The first stage of any risk assessment is to identify, using the desk study data and site information, the presence and extent of any hazard at the site, theoretical or demonstrable.

A key component of the overall risk assessment process is identification of “significant contamination linkages” between contaminants and receptors. This can be accomplished through development of a site-specific conceptual model in which the potential contaminants, pathways and receptors identified on-site are described.

Each element can be defined as follows:

- **Contaminant source:** A substance either on or under the land and which has the potential to cause harm or pollution to human or environmental receptors.
- **Pathway:** A route or means by which a receptor can be exposed to or affected by a source.
- **Receptor:** A living organism or an ecological system or, controlled water, or property including buildings, crops and livestock.

The presence of all three of the above elements identifies a contamination linkage and a potentially unacceptable risk. To ensure that any risk present to, or, from the site can be appropriately managed each of these contamination linkages will be targeted by the investigation.

Conceptual Models have been derived in a series of the earlier reports including (Ref 4 and Ref 7), these will be incorporated into the following model, which will aim to address known potential issues on the site.

19.1 Sources

The key identified contaminant sources on the site are as follows:

19.1.1 Combustible Shallow Soils and Asbestos

Assessment to date indicates that almost the entire Stockyard area and a small portion in the northwest corner of the Production and By-Products area is surfaced with a mantle of ‘breeze’ a black, coke dust rich substrate, which appears to be predominantly of a high calorific value and potentially flammable. This material appears to have originated from use of this area for storage of coal and coke products.

Data Gaps: Additional testing of the top 0.5m of this material has identified Chrysotile asbestos within this material, however, due to a low density of sampling at this depth, it is unclear as to whether this impact is localised, sporadic or widespread and there is no assessment of the severity of this undertaken to date.

19.1.2 PAH, Metal and Asbestos Contamination within Made Ground

Made Ground is present across almost the entire site and makes up most of the superficial soil deposits identified, this predominantly comprises granular fill of rubble, coke, and ash. This material has been deposited from the demolition and deposition of rubble associated with multiple



generations of plant and equipment over with the industrial heritage of the site. As a result, this forms a highly variable substrate.

Due to the nature of this material testing has encountered hotspots of PAH and metals from coking wastes in numerous locations spread across the Stockyard and Production and By-Product areas of the site.

In addition, potential infilling of materials, namely in the untested 'Unused Area' in the Stockyard poses a potential hazard due to the unknown nature of its composition.

This material is likely to remain variable throughout its entire volume, further characterisation would be unlikely to alter the classification of this material.

19.1.3 Hydrocarbon and Tar / Oil Contamination

The walkover of the Production and By-Products area indicated numerous potential point sources for spills and leaks of a wide range of contaminants, by-products and wastes, frequently in leachable liquids with the potential to have entered into the underlying ground and groundwater from leaks, spills and historical waste management practices.

Due to restrictions placed on earlier investigations, as the site was still active at the time, the number of samples and detail of the investigation in this area is of a relatively low density compared with the very high number of potential contaminant sources. Much of this area is poorly understood with little reliable information on the groundwater regime in this area. Existing trial pit logs have indicated a significant number of buried obstructions in this area

Available testing from the Made Ground and Groundwater in the Production and By-Products areas of the site has identified potentially significantly elevated concentrations of PAH contamination which are considered likely to be associated with leaks and spills from these processes (rather than due to the composition of the rubble matrix), based on a review of corresponding trial pit and borehole logs. Figure 7 in Appendix A shows the areas of known elevated PAH, hydrocarbon and tars within soils and also within the underlying groundwater, encountered at a greater depth in the bedrock.

One location, along the western boundary of the site identified what is likely to be Coal Tar, as a DNAPL, close to the old boiler plant, whilst this has not been identified elsewhere, it is likely to be connected to wider source in the area as suggested by the visual identification of tars and NAPLs within soils in BH204, BH205, MW5 and MW6.

Data Gaps: Due to the limited investigation in the Production and By-Products areas, the areas of impact are likely to extend into other areas around the former coke ovens, CHP plant and exhaust house (in the east of the Production area).

Data Gaps: DNAPL is likely to be more widespread than identified here.

19.1.4 Silica Bricks

Stockpiled bricks onsite are understood to contain an elevated amount of Silica, which if processed may present a human health risk. These are currently formed into a stockpile in the former Stockyard and Production areas of the site.

These are considered in Ref 17 as suitable for reuse onsite provided, they are processed appropriately and as such will not be considered a contaminant source.

19.1.5 Ground Gases

Ground gases are understood to have been sampled from numerous locations, however limited data has been made available to Geo². Ground gases may emanate from numerous sources including contaminated land, infilled materials and coal deposits.

Projected areas of infill such as the Clay pit in the north, do not appear to contain significant volumes of infilled materials.

The area of the former sandstone quarry, beneath the current Hargreaves building is unknown, however this will be considered as offsite for this assessment.

Data Gap: Gas data remains limited and further historic data should be sought, or new assessments undertaken.

Data Gap: The composition of the 'Unused Land' in the northeast corner remains unknown.

19.2 Pathways

The key pathways by which contaminants might pose a risk on the site are as follows:

19.2.1 Direct Contact, Inhalation and Ingestion

Shallow contamination, either at the current or future land levels, may pose a risk through exposure at surface to future land users. Laboratory testing to date, has indicated potentially unacceptable contamination is present in shallow soils.

19.2.2 Groundwater Migration

Groundwater beneath the site is quite poorly understood, with no clear flow direction or clear waterbodies established across large areas. Broadly the groundwater is present within the underlying bedrock beneath the site.

In the Stockyard area, which appears better understood, groundwater appears to display limited evidence of contamination.

However, in the Production and By-Products area, clear evidence of DNAPL and potentially gross groundwater impact has been noted, which demonstrates that this pathway may carry contamination offsite, downgradient.

19.2.3 Accumulation of Vapours or Gases

This may occur indoor in enclosed spaces and might result from vapours emanating from hydrocarbons or ground gases which might cause harm should these migrate into properties on, or off the site. This pathway includes the potential for the tainting of water supply pipes.

19.3 Receptors

The key receptors on and nearby the site have been identified as the following:

19.3.1 Future Residential Site Users

It is understood that the site has a proposed residential end use, at this stage no clear or final development plans have been provided.

It is understood that the Client proposed to increase the final site levels to reflect the surrounding land and to achieve this a degree of import or releveling will be required. Consideration must be given to the vulnerability of this receptor at the final site levels, from any potentially contaminated materials.

No assessment is made here for construction workers, who should be made aware of potential hazards on the site and take appropriate steps through a Site-Specific Health and Safety Working Plan and Environmental Statement to ensure potential impacts during redevelopment can be minimised or mitigated.

19.3.2 Offsite Land Users

These take the form of nearby industrial neighbours of the site, the Timber Yard to the West and former Coal Yard to the north. Residential land users have been identified at a distance in excess of 100m from the site boundary.

For the purposes of this assessment the Hargreaves office building on the eastern boundary will be considered as offsite and must be considered as a viable receptor, through close proximity to the site.

On the basis of current site data there is little evidence to indicate a potential hazard to offsite land users, however they should be considered in the event of any proposed remediation or redevelopment works.

19.3.3 Controlled Waters

The underlying aquifer is classified as a Secondary A aquifer, within the bedrock although the site is not noted as falling within a Source Protection Zone. The permeability of the sandstone bedrock and degree of identified impact within this water body does indicate that this waterbody may have already become impacted. There is currently insufficient evidence to demonstrate whether there is any form of contamination plume in the groundwater.

Nearby surface water channels are located along the western site boundary, namely Lineside Dyke and Wakefield Brook, located topographically downgradient, and running close to the railway line. These watercourses may be ephemeral or relatively minor, however, these may act as a receiving water for migrating contamination. Sampling has been undertaken of surface waters (Ref 2, 3), although the locations of these samples is unclear

Additionally, the presence of relict drainage, most likely in the Production and By-Products area, may allow transmission of contaminants into surface waters or drainage channels through preferential pathways, currently unidentified.

19.3.4 Sensitive Land Uses

A review of supplied desk study data has not indicated any sensitive nearby land uses beyond those detailed above. This will not be considered further in this assessment.

19.3.5 Structures Onsite

As all onsite structures are to be removed, the risks from aggressive ground conditions to future buildings should be considered at design stage. This will not be considered further in this assessment.

19.4 Contaminant Linkages

Each of the identified plausible contamination linkages in the conceptual site model is reviewed based upon the findings of the site investigation which allows a greater understanding of the ground conditions at the site, site observations, soil and groundwater quality and chemical analysis.

A qualitative risk assessment is undertaken in line with guidance provided in *Guidance for the Safe Development of Housing on Land Affected by Contamination* (EA / NHBC, 2008). The purpose of this assessment is to determine the relative significance of the identified contamination linkages by assessing the probability of an impact occurring and by assessing the perceived severity of an impact to a receptor.

Those linkages considered of low risk or less on the basis of the additional site data will not be considered any further in this assessment. Linkages considered to be more significant are identified as presenting the potentially significant hazard, which may present a potentially unacceptable risk to the identified receptor. In these instances, further works may be considered necessary to characterise these risks adequately.

The contaminant linkage table below has been updated and adopted from the RSK (Ref 2) 2011 report and Patrick Parsons (Remediation strategy report (Ref 17), 2017, as well as information gleaned from all supplied documents.

Potential Source	Potential Pathway	Potential Receptor	Likelihood	Severity	Risk
Combustible Shallow Soils	Direct contact, exposure, plus instability risk in event of fire	Future residential site users.	Likely	Severe	High risk
PAH, Metal and Asbestos Contamination within Made Ground	Direct contact, ingestion and inhalation.	Future residential site users	Low Likelihood	Medium	Moderate Risk
Hydrocarbon and Tar / Oil Contamination	Direct contact, ingestion and inhalation.	Future residential site users	Low Likelihood	Medium	Moderate Risk
		Controlled Waters	Likely	Medium	Moderate Risk
		Offsite Landusers	Low Likelihood	Mild	Low Risk
Ground Gases	Accumulation of Vapours or Gases	Future residential site users	Likely	Medium	Moderate Risk
		Offsite Landusers	Low Likelihood	Mild	Low Risk

Table 8: Qualitative Risk Assessment

20.0 OUTLINE DEVELOPMENT CONSIDERATIONS

20.1 Development Constraints

There are a number of constraints on development which are detailed in the 2017 Patrick Parsons Remediation Strategy (Ref 17) and as shown on Figure 5, in Appendix A. A number of these comments highlights further data gaps, pertinent to a future development.

In addition to the contaminant linkages identified in Section 19.0, which remain unresolved, the following items (drawn from Ref 17 and supplemented from other sources) will require further characterisation in order to facilitate the proposed redevelopment of the site. Where items detailed in Ref 17 have been covered in the earlier section, they will not be duplicated here.

- A possible railway tunnel has been suggested in the Stockyard area. This requires further investigation to confirm its location, depth and nature in order to inform future development plans.
- Three capped mine shafts have been identified in the Stockyard area. Consideration should be given to identifying the location of these features and potentially to undertaking capping competence assessments or excluding from structural development.
- Potential shallow coal mining has been indicated in the Southern Area, which may require treatment if encountered. Further assessment is required in order to gain confidence in the sub cropping deposits as existing data, which broadly suggests no coal to be present, is considered by Geo² to be insufficient to base a sound assessment upon. Ref 8, the Coal Mining Risk Assessment states that *'there is a low risk from unrecorded or recorded shallow workings at the site and therefore no specific mitigation strategy is required for potential shallow coal workings. There is a residual risk to the proposed development from unrecorded mine entries and backfilled areas of previous opencast mining. Therefore, it is recommended that all excavations during development works are inspected for evidence of mine entries.'* It should be noted that this report has no author and Geo² do not consider that the Client has reliance upon this.
- Infilling of former clay pits, in the extreme north of the Stockyard has been highlighted as a concern potentially requiring further ground gas testing, however a review of available data in this area suggests no evidence of deposition of infill to any greater thickness than exhibited elsewhere in this area. The quarry in the south (mentioned in Ref 17), is considered predominately to lie offsite (in Hargreaves land) and has been discounted from this assessment.
- The 'Unused Area' which has also been flagged as a potential unknown in the contamination assessment, referred here as a soil bund and taken to mean the unused area and site boundary, including the deposited tyre wall, represents an unknown for its geotechnical and chemical condition.
- All structures and tanks should be demolished or decommissioned and removed appropriately from site. Remnant buried foundations and substructures will represent a significant hinderance to earthworks and foundations (as well as additional site characterisation works). Consideration should be given to the grubbing up of these obstructions as part of any redevelopment scope.
- Japanese knotweed has been identified, but poorly delineated, along the northern boundary and in the 'Unused Area'.